

SPECIFICATIONS AND DRAWINGS

REFURBISHMENT OF SUBSTATIONS AT THE PORT OF CAPE TOWN, CONTAINER TERMINAL OF TRANSNET SOC LTD (REG.NO.1990/000900/30) OPERATING AS TRANSNET PORT TERMINALS, (HEREINAFTER REFERRED TO AS "TPT") FOR A PERIOD OF TWENTY-FOUR (24) MONTHS


TECHNICAL SPECIFICATION:

ANNEXURE P – ETAP SPECIFICATION

SPECIFICATION FOR SUPPLY OF ETAP

ANNEXURE P – ETAP SPECIFICATION

Document Reference	Title	Number Of Pages
	<p>SPECIFICATION FOR SUPPLY OF ETAP SOFTWARE LICENSE FOR TRANSNET SOC LTD (REG. NO. 1990/000900/30) OPERATING AS TRANSNET PORT TERMINALS (HEREINAFTER REFERRED TO AS "TPT")</p>	<p>6</p>
	<p>Total number of pages</p>	<p>6</p>

REVISIONS		
REV	DATE	APPROVED
	07/11/2024	
	11/11/2025	

1. INTRODUCTION

TPT requests delivery from the contractor to provide an ETAP software modelling and simulation tool with a single standalone license.



2. BACKGROUND

ETAP is a software for electrical power systems modelling and simulation, optimizing customer electricity power systems from design and engineering to operations and maintenance.

ETAP delivers best-in-class, seamless customer experience and ensuring universal and Morden accessibility for designers, engineers, and operators empowering users to increase productivity, collaboration, and efficiency, and enabling the energy transition journey.

3. PURPOSE

Request for the supply of ETAP software.

4. SCOPE OF THE SPECIFICATION.

4.1 The *Contractor* shall in collaboration with the employer’s ICT department ensure that the software, with all modules, is functional.

4.2 The *Contractor* shall arrange for training on all modules for four employer’s personnel. The training shall be a formal training for users.

4.3 Details of software licence:

- The *Contractor* shall provide a new standalone licence with a standard support for the duration of 1 to 3 years.
- The bus level shall be **5000 buses**.

5. SPECIFIC DELIVERABLES FOR THE SUPPLY of ETAP SOFTWARE LICENSES

The most recent version of ETAP software shall be supplied with the modules and specifications listed below:

Item Description	Maintenance Term	Licence Metrics	Quantity

SPECIFICATION FOR THE SUPPLY OF ETAP SOFTWARE LICENSE FOR TRANSNET SOC LTD (REG. NO. 1990/000900/30) OPERATING AS TRANSNET PORT TERMINALS (HEREINAFTER REFERRED TO AS "TPT").

ETAP New License – 1 Single Commercial SA, unlimited Bus:		In line with the standard offer.	Fixed/Standal one.	1
Base Module	Multi-Dimension Digital-Twin Platform, Revisions, Libraries, Wizards			
IEEE, ICEA, NEC	Cable Ampacity & Sizing - IEEE, ICEA, NEC			
IEC 60502 & 60364	Cable Capacity, Sizing & Shock Protection - IEC 60502 & IEC 60364			
Load Flow, AC	Power Flow, 3-Phase & 1-Phase Systems, Voltage Drop, Result Analyzer			
Panel Schedule	Schedules, Calculations, 3-Phase, 1-Phase, NEC, IEC			
Renewables	Wind Turbine Generator, PV Array - PV Pro, Controls, Libraries, Profiles			
HVDC	Control Schemes, Dynamic Modes,			

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	Rectification, Inversion			
Short Circuit, AC	ANSI & IEC, Balanced 3- Phase & 1- Phase, Duty Evaluation, Analyzer			
Arc Flash, AC	IEEE 1584 2018 & NFPA 70E 2021 - Analyzer, Work Permit, Safety Labels			
Star	Protection, Selectivity, Sequence of Operation, Protective Devices			
Star Auto-Eval	Auto-Evaluation of Protection, Selectivity, Zone, Arc Flash*			
Harmonics	Harmonic Load Flow, Frequency Scan, Harmonic Filters & Sizing			
Ground Grid	3D Ground Grid Systems, IEEE 80 & 665, Finite Element (Irregular Grids)			

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Cable UG Thermal	UG Raceways, Direct Buried, Neher-McGrath, IEC 60287			
Load Flow, DC	Voltage Drop, Power Losses, Reports, IEEE 946			
Battery Sizing	Battery Discharge & Sizing, IEEE 308, 485, 946, Integrated with Control Simulator			
Renewable energy				

The Service Provider is required to provide the following as part of the deliverables:

1. Provide the ETAP licence software inclusive of all design modules.
2. Installation and testing of all modules.
3. Technical and backup support for the period of licencing or as a standard offer for the licence.
4. Accredited/ETAP approved formal training on all modules for four users.

TECHNICAL SPECIFICATION:

Annexure_3_4 Test Reqs & Statement of Compliance

TEST REQUIREMENTS

ANNEXURE 3

TEST REQUIREMENTS

1. TYPE TESTS

- 1.1 Type testing shall be carried out in accordance with the Recommendations, Standards, or Specifications referred to in this specification.
- 1.1.1 Type test certificates shall be submitted with tender documents.

2. ROUTINE TESTS

- 2.1 The following additional routine tests shall be carried out on the completed switchgear or control gear at the Manufacturers works prior to delivery.
- 2.2 The ratio, polarity and magnetism curve of each current transformer after their installation in the board.
- 2.3 The characteristic curves of each protection relay where applicable.
- 2.4 The ratio of each voltage transformer.
- 2.5 The errors of all indicating instruments.

3. FUNCTIONAL TESTS

- 3.1 A functional test of the complete board including all protective relays by primary injection shall be carried out by the manufacturer.
- 3.2 The breaker opening times shall be indicated in these tests.

4. GENERAL

- 4.1 Four copies of all approved routine test certificates shall be supplied, at a date not later than the delivery date of the switchgear or control gear.
- 4.2 All routine testing shall be witnessed and inspection carried out by the Engineer (Electrical) or his duly appointed representative.


TECHNICAL SPECIFICATION:


High Level Commissioning Plan




Transnet Port Terminals High Level Commissioning Plan Electrical Equipment

Document No:

Prepared by: Name: Samukelo Magcaba Date: May 2018
Signature:  Date

Reviewed by: Name: Samukelo Magcaba Date: 11/11/2025
Signature:  Date

Approved by: Name: Samukelo Magcaba Date: September 2022
Signature:  Date 11/11/2025

Rev	Date	Revision Details
00	November 2025	Issued for Tender
00	May 2018	Issued for Review



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1. INTRODUCTION

The purpose of the High Level Commissioning Plan is to outline the procedures associated with commissioning various types of electrical and mechanical systems and equipment. A detailed commissioning plan as where deemed appropriate at the discretion of the responsible engineer, shall be prepared as required for the various systems. International best practice norms and standards shall be followed in terms of inspection, testing for safety, setting and configuring, and rendering the installed equipment fully functional to its intended purpose.

2. STATUTORY REQUIREMENTS

All aspects of the commissioning process shall adhere to any and all relevant requirements of the following legislation, as appropriate:

- Occupational Health and Safety Act 85 of 1993
- National Environmental Management Act 107 of 1998
- South African National Standards and Codes of Practice
- All local, provincial or S.A. Government laws in force at the time.

3. GOVERNING CODES, STANDARDS AND SPECIFICATIONS

The commissioning process for all electrical and mechanical equipment shall adhere to any specific and relevant requirements contained in the following national and international standards. Where different standards call for different testing and commissioning procedures for the same equipment, the most stringent alternative shall apply.

Note: Where reference is made to a code, standard or specification, the reference shall be taken to mean the latest edition of the code, standard or specification, including latest Addenda, supplements and revisions thereto.

The commission process in general, shall be in accordance with the recommendations of:

- ◆ The International Electrotechnical Commission (IEC), and
- ◆ The Institute of Electrical and Electronic Engineers (IEEE)
- ◆ International Standards and Codes – ISO, DIN, BS, ASME, ASCE, ANSI, ASTM, EU

4. SCOPE

This plan covers site electrical pre-operational tests and commissioning tests required for electrical apparatus, wire, cables and other miscellaneous equipment and material as called for in the specifications and must be read in conjunction with the other specifications.

5. GENERAL INFORMATION

- 5.1. Pre-operational tests and acceptance certificates as herein specified are defined as those tests and inspections required by the ENGINEER prior to equipment being energized to



determine that the apparatus involved may be safely energized.

- 5.2. Calibrating tests, checks on limit switch settings, interlocking, PLC functioning etc. are so called cold commissioning or dry tests.
- 5.3. Hot commissioning tests are the tests as specified by the Engineer such as burn in tests for electronic equipment and continuous cycle tests etc. when the equipment is handling the product it was designed for.
- 5.4. Final acceptance will not only depend on equipment dependability, as determined by the subject tests, but will depend on complete operational tests on all equipment to show that the equipment will perform the functions for which it was designed.
- 5.5. These specifications intend that the workmanship methods, inspections and materials used in erection and installation of the subject equipment shall conform with accepted engineering practices, the specifications as prepared by the Engineer, Manufacturer's instructions and the relevant Standards as referred to in all the attached specifications.
- 5.6. **Thermographic images shall be taken, as directed by the Engineer, of all equipment put into service, as part of the commissioning documentation. These images shall be time and date stamped.**
- 5.7. The Contractor shall bear the costs of all tests required.

6. RESPONSIBILITY

- 6.1. The testing shall be performed by and under the immediate supervision of the Contractor and witnessed by the Engineer and/or his duly authorised representative. This representative may be an Independent Commissioning Engineer appointed by the contractor with the Engineer's approval.
- 6.2. The Contractor shall adjust, set, co-ordinate, calibrate and test all systems and equipment furnished and/or installed by him.
- 6.3. The Contractor shall determine, and the Engineer shall approve the individuals in whom final responsibility and authority rests for carrying out these tests and inspection procedures on particular equipment. The method to be followed in obtaining clearances on electrical equipment shall also be established and such method rigidly adhered to.
- 6.4. All testing shall be scheduled by the Contractor and cleared through the Engineer. No testing of any kind shall be done or scheduled without this clearance.
- 6.5. The Contractor shall notify in person or by letter all the interested parties at least 24 hours prior to tests, establishing the time the test is to be performed.
- 6.6. The interested parties to be informed will be determined in conjunction with the Engineer.
- 6.7. The parties notified shall be responsible for having their representatives present at the designated time. Absence of any one representative will not prohibit the test from proceeding on schedule, unless such representative is essential in doing the tests.
- 6.8. Each of the notified interested parties and the testers employed shall be individually responsible for the safety of all members of their organization during such time as the tests



are performed.

- 6.9. The Contractor will coordinate all testing to ensure that all trades are prepared and that the conditions are safe.
- 6.10. Detailed testing method and equipment shall be approved by the Engineer.
- 6.11. On some tests, particularly the final inspections of important equipment, the manufacturer's Engineer or representative shall be present and perform same. The request for a manufacturer's representative shall be made sufficiently in advance to the date the test is scheduled so that satisfactory arrangements for the representative's services can be made. Frequently, the manufacturer's responsibility applies to both electrical and mechanical equipment. Where such joint responsibility exists, the request for a manufacturer's representative shall be arranged to satisfy both electrical and mechanical requirements simultaneously.
- 6.12. Manufacturer's instructions shall be carefully read for any special conditions that may be required for testing.
- 6.13. Following established procedures, equipment will be energized after certification on the relevant form by the personnel performing the tests, that equipment is ready for energizing and with the concurrence of the Engineer.



7. TESTING EQUIPMENT

- 7.1. All testing equipment for tests which are to be performed shall be furnished by the Contractor.
- 7.2. Testing equipment required to prove guarantee values shall be calibrated immediately prior to the relevant tests to be performed. The error curves shall be submitted with the report.

8. TESTING RECORDS

- 8.1. Test results shall be entered in test forms provided by the Contractor or, if such forms are not available, in test forms approved by the Engineer.
- 8.2. Authorized, qualified representatives of the parties interested (see paragraph 3.0 shall be present to approve a test when made. One (1) copy of the rough draft-test report shall be given to each authorized representative at the time the test is made.
- 8.3. Formal test reports approved by the Engineer shall be supplied and prepared by the party performing the test within 48 hours, signed by the authorized representatives, and furnished to the Engineer for distribution.

9. SAFETY PRECAUTIONS

- 9.1. The Contractor shall exercise extreme care in performing the tests specified so as not to jeopardize the safety of personnel and to prevent equipment damage during any tests. All exposed live parts subject to testing shall be guarded by personnel, barricades, or other practical means to ensure against personnel being injured by coming in contact or close proximity to exposed parts.
- 9.2. All equipment, exposed live parts, etc., shall be completely discharged by grounding or other accepted methods so as to eliminate the possibility of injury to personnel from electrical shock after the tests have been completed.

10. PROVISIONAL ACCEPTANCE

- 10.1. The Engineer's Provisional Acceptance of any electrical installation shall be based upon the completion of tests and checks prescribed in clauses 8 through 13, submission of test data (where required), satisfactory materials and workmanship, and demonstration of satisfactory start-up.

11. EARTH CONTINUITY AND RESISTANCE TESTS

11.1. General:

- 11.1.1. All earthing and bonding cables must be checked for continuity and earth resistance.

11.2. Test procedure:

- 11.2.1. Measuring the cable and connection resistance simultaneously with a resistance bridge or accurate multi-meter.

11.3. Acceptance:

- 11.3.1. The resistance of the earthing and bonding cables and connections must be less than stated in SABS 0142/latest.
- 11.3.2. Complete and accurate records of all resistance readings of all earthing conductors of motors, transformers, power cables etc. must be made.

The records shall include the following:

- 11.3.2.1. Complete identification of the cable and connection points including its approximate length;
- 11.3.2.2. Resistance reading;
- 11.3.2.3. The approximate average cable temperature.
- 11.3.3. No electrical systems will be energized until the master copy of its test record is approved by the Engineer.

12. MEDIUM VOLTAGE CABLES

12.1. General:

- 12.1.1. The Contractor shall give all medium voltage cables a Very Low Frequency (VLF) Hi Pot test in compliance with the cable manufacturers specifications, after all splices and potheads or cable terminations have been made.
- 12.1.2. The Contractor shall then perform a Dissipation Factor (Tan-Delta) test on the cable as per the cable manufacturer's specifications.
- 12.1.3. The medium voltage cables shall be given a complete dielectric absorption test before and after the VLF and Tan-Delta test. The cable test shall be performed prior to connections to the electrical equipment at either end.
- 12.1.4. DC Hi Pot Testing is strictly prohibited on any MV cables or systems owned and operated by Transnet.
- 12.1.5. The Contractor shall supply all instruments for testing.



12.2. Test Procedures:

- 12.2.1. Medium voltage stress cone type terminations or potheads shall remain intact but testing shall not include any bus work beyond the pothead or stress termination.
- 12.2.2. Cable continuity and phase identification shall be checked.
- 12.2.3. In setting up the test set special safety precautions should be taken regarding grounding of the test equipment. The test set, it's voltmeter and the cable shield should be grounded at the same ground.
- 12.2.4. All 4 core cables shall be tested between one conductor and ground with the other conductors and the metallic shield, metallic sheath or armour grounded to the same ground. Each conductor to be tested in this manner.
- 12.2.5. All single conductor cables shall also be tested between one conductor and ground with the other conductor in the same conduit grounded.
- 12.2.6. Each cable is to be given a full dielectric absorption test as herein specified with a suitable motor driven or electronic megger. The readings taken shall be recorded in the test record.
- 12.2.7. The dielectrical absorption megger test shall be applied for a long enough duration to fully charge the cable. Megger readings shall be taken every fifteen (15) seconds during the first three (3) minutes and at one (1) minute intervals thereafter. The test shall continue until three (3) equal readings one (1) minute apart are obtained. The cable may then be considered to be fully charged.
- 12.2.8. All cables should have approximately the same megohm reading. In the event that a cable shows an appreciably lower resistance value than the others in the same conduit or cable run, this condition shall be discussed with the Engineer prior to the application of the high potential test.
- 12.2.9. After an acceptable megger test, the Contractor shall give the cables a VLF high potential test in accordance with the requirements of IEEE 400.2-2013. After completion of the test, the contractor shall ensure that there is no residual charge contained in the cables. Any cable that does not perform as per manufacturer's specifications shall be rejected.



- 12.2.10. Cables shall then be subjected to the Tan-Delta testing.
- 12.2.11. The successful high potential test shall be immediately followed by another megger test as heretofore specified.

12.3. Acceptance:

- 12.3.1. The cable must withstand the specified high voltage without an appreciable increase in leakage current.
- 12.3.2. Final acceptance will also depend on satisfactory results of the two megger tests. The results of the final megger test should reasonably parallel those of the first megger test and should show no evidence of differing performance prior to the VLF Hi-Pot and Tan-Delta Testing.
- 12.3.3. Complete and accurate records of all megger and accompanying VLF and Tan-Delta tests shall be made. The records shall include the following:-
 - 12.3.3.1. Complete identification of the cable including its approximate length;
 - 12.3.3.2. Megger readings vs time data;
 - 12.3.3.3. VLF and Tan-Delta test results with date and time of test.
 - 12.3.3.4. The approximate average cable temperature taken by Thermographic Imager, with images recorded along the entire length of cable.
- 12.3.4. No cable shall be energized until the master copy of its test record is approved by the Engineer.

13. LOW VOLTAGE POWER CABLES

13.1. General:

- 13.1.1. All wires and cables shall be tested for continuity. Except for 60 volt services and below, all wires and cables shall be given a megger test.
- 13.1.2. All cable connections must pass visual inspections for workmanship and conformance with standard practice.

13.2. Test Procedure:

- 13.2.1. Continuity shall be checked by means of a DC test device using a beeper.



- 13.2.2. Bus tie cables shall be meggered before connections to buses are made.
- 13.2.3. Each 400 volt service cable from substations shall be meggered with the cable connected to the switch gear with the corresponding breaker racked in and open. Connections at the other end of each of these cables shall be as follows:-
 - 13.2.3.1. Cables to individual motors shall be disconnected from the motor for initial tests, and followed by cables connected to motors as per specification for rotating equipment;
 - 13.2.3.2. Cables to control centres shall be connected to the control centre main breaker with breaker in the open position.
- 13.2.4. Minimum megger readings shall be 1 Me 6 ohm.
- 13.2.5. The megger test must be held until the reading reaches a constant value. For 400 volt cables the cable megger test shall be held until three (3) equal readings, each one (1) minute apart, are obtained.
- 13.2.6. A 1000 volt motor-driven or electronic megger with a value of at least twice that of the RMS voltage shall be used on all service conductors.
- 13.3. Acceptance:
 - 13.3.1. Minimum megger requirements must be met.
 - 13.3.2. Any cable having a megger reading 50% lower than average, even though meeting minimum requirements, shall await further instructions from the Engineer as to drying or other treatment to be given the cable prior to acceptance.
 - 13.3.3. Complete and accurate records of all tests and inspections shall be made.

14. MEDIUM VOLTAGE SWITCH GEAR AND CIRCUIT BREAKERS

- 14.1. General:
 - 14.1.1. All switch gear shall be given operational tests. This shall include mechanical operation, as well as operation by control circuits, relays and tripping devices. All breakers and busbars shall be given a megger test.



14.2. Test Procedures:

- 14.2.1. Megger tests on the medium voltage bus shall be applied between each phase separately and ground with other phases tied to ground. All breakers shall be racked-out.
- 14.2.2. In addition each breaker shall be given a megger test in the racked-out and closed position. Megger tests shall be applied between each phase to ground and to each other phase.
- 14.2.3. A suitable motor driven or electronic megger shall be used. Each test shall be held until a constant reading is obtained. Minimum test values shall be as specified in specifications.
- 14.2.4. All test readings shall be recorded.
- 14.2.5. All circuit breakers shall be operated through at least three (3) open-close-open cycles in both the rack-in and test positions by manual operation and by control circuits from each control point. All indication lights, annunciators, alarms and targets shall be observed to determine correct operation and breaker mechanism shall be observed for correct alignment, freedom of binding and good contact. All breakers shall be checked for ease of rack-in and rack-out and checked to determine that the breaker cannot be moved out of operation position while the breaker is closed.
- 14.2.6. The interchangeability of the circuit breakers shall be demonstrated.
- 14.2.7. PT and CT data shall be recorded and PT and CT circuits shall be checked with a multi-tester.
- 14.2.8. Protective relays shall be adjusted and calibrated with an injection type test arrangement (multi-amp or equal). Results shall be recorded and the co-ordination of the protective relaying shall be proved.
- 14.2.9. After initial energization, switch gear shall be checked for correct phase sequence.

14.3. Acceptance:

- 14.3.1. Minimum megger requirements must be met;
- 14.3.2. Proper mechanical and electrical operation of switch gear must be assured;
- 14.3.3. Correct protective relaying operation must be proven;
- 14.3.4. Complete and accurate records of all tests and inspections shall be made.

15. POWER TRANSFORMERS

15.1. General:

- 15.1.1. Before testing, all transformers shall be inspected for cleanliness, damage, moisture (blue coloured silica gel), oil leaks and phase identification. Each transformer winding shall be given megger tests.
- 15.1.2. Oil filled transformers shall have the oil checked for dielectric strength.
- 15.1.3. Accessories and auxiliary circuits to switchgear and alarm panels shall be checked.

15.2. Test Procedures:

- 15.2.1. Transformer windings shall be meggered with cables disconnected. (The cables have to be disconnected anyhow for cable high potential tests). See clause 9.0.
- 15.2.2. The 400 volt connection to the switchgear does not have to be opened, but the secondary isolator shall be racked out.
- 15.2.3. The transformer neutral has to be disconnected from ground.
- 15.2.4. When meggering the primary side, the secondary winding has to be grounded and vice versa.
- 15.2.5. The minimum values of the specified megger tests shall be as specified in the standard specification.
- 15.2.6. All 2500 V megger tests shall be held at least five (5) minutes and until three (3) consecutive equal readings one (1) minute apart are obtained. Readings shall be taken every thirty (30) seconds during the first two (2) minutes and every minute thereafter. 1000 V Megger readings must be held until the reading reaches a constant value and until three (3) consecutive equal readings one (1) minute apart are obtained.
- 15.2.7. The oil samples for the dielectric strength test shall be taken from the bottom of the transformer tank and tested in accordance with SABS Specifications.
- 15.2.8. Oil temperature indicator, level gauge and pressure relief devices must be manually actuated to check operation of auxiliary circuits.
- 15.2.9. To check the Bucholz relay, air shall be injected at the test connection.



15.3. Acceptance:

15.3.1. Minimum megger requirements must be met.

15.3.2. Oil dielectric strength shall be above the minimum specified by the manufacturer.

15.3.3. Auxiliary circuits shall be fully operational.

16. LOW VOLTAGE SWITCH GEAR

16.1. General:

16.1.1. The 400 volt switch gear bus shall be given a phase-to phase and phase-to-ground megger test.

16.1.2. All switch gear, relays and control devices shall be given complete operational tests to show that the equipment performs all design functions and meets design and equipment procurement specifications.

16.2. Test Procedures:

16.2.1. With transformer secondary breaker and load breakers open, all current transformers shorted, all potential transformer fuses removed and all 400 volt feeder breaker load terminals grounded, the 400 volt bus shall be given a phase-to-phase and phase-to-ground megger test.

16.2.2. Megger tests on the 400 volt bus shall be applied between each phase and ground with phases not under test also grounded.

16.2.3. All circuit breakers shall be operated through at least three (3) open-close-open cycles in both the rack-in and test position by manual operation and by control circuits from each control point (draw out breakers only). All indicating lights, annunciators, and breaker mechanisms shall be observed for correct alignment, freedom of binding and good contact. Draw out breakers shall be checked for ease of rack-in and rack-out and checked to determine that the breaker cannot be moved out of operating position while the breaker is closed.

16.2.4. PT and CT data shall be recorded and PT and CT circuits shall be checked with a multi-tester.

16.2.5. Protective relays shall be adjusted and calibrated with an injection type test arrangement (multi-amp or equal). Results shall be recorded and the co-ordination of the protective relaying shall be proved.



16.2.6. After initial energization, switch gear shall be checked for correct phase sequence.

16.3. Acceptance:

16.3.1. Minimum megger requirements must be met.

16.3.2. Proper mechanical and electrical operation of switch gear must be assured.

16.3.3. Correct protective relaying operation must be proven.

16.3.4. Complete and accurate records of all tests and inspections shall be made.

17. COLD COMMISSIONING

17.1. The programmable logic control system shall only be tested once the LV switchboard and other control panels have been tested in the manual mode and been provisionally accepted by the Engineer.

17.2. The control system shall firstly be tested DRY, i.e. all motor fuses shall be removed or circuit breakers shall be in the OPEN positions.

17.3. All plant/external inputs to the PLC shall be individually checked in the field or motor control centre by operating the required field limit switch, relays etc. and checked on the programmer monitor if the status indication of the correct input reference alters.

17.4. All plant/external outputs shall be checked individually by forcing the PLC output coil by means of the programming unit and checking the field, motor control or mimic display panel if the correct relay, indication lamp or contactor has operated.

17.5. A signed test record showing all input/ output references and reference to which field, motor control centre or mimic panel device was initiated or was operated shall be made and handed to the Engineer before the second part of the DRY test commences.

17.6. The second part of the DRY test shall be by carrying out drive selections, route start ups and route stops for all possible drives as listed. All inputs which cannot be present because of the absence of any plant movement shall be simulated by a plant input simulator to be provided by the Contractor.

17.7. Upon completion of the tests, a signed test record showing all route selections, starts and stops simulated for every route and a list of all simulated inputs/outputs used shall be made and handed to the Engineer.

17.8. The Contractor shall then call upon the Engineer to witness a repetition of all previous DRY tests.

18. HOT COMMISSIONING

- 18.1. Commissioning of the whole installation shall not commence until all work which is essential for safe operation has been completed.
- 18.2. First, the electrical equipment and circuitry shall be checked and tested in each Motor Control Board and shall be rendered "healthy" and fully operational before any other part of the installation is commissioned.
- 18.3. The settings of all protective, instrument and timing devices are to be correctly based on the manufacturer's characteristic curves.
- 18.4. The operation of all equipment and motors shall be tested on the "manual" sequence first prior to attempting "automatic" sequence control.
- 18.5. Commissioning shall follow the electrical testing procedures necessary prior to start-up of the equipment.
- 18.6. The start-up of each system or plant shall be done in the presence of the authorized representatives of the machine suppliers, the mechanical contractors, the electrical suppliers of the boards, the Electrical Contractor and the Engineer, unless otherwise arranged by the Engineer.
- 18.7. During hot commissioning the temperature rise of all motors will be calculated using the resistance method.
- 18.8. For a period determined elsewhere in this document, after completion of the foregoing operations, the Electrical Contractor shall arrange for a competent representative to remain on site to test-run the installation to the satisfaction of the Engineer.

TECHNICAL SPECIFICATION:

Specification No. TCPELE014TRANSFORMER

**SPECIFICATION FOR THE SUPPLY, DELIVERY AND
INSTALLATION OF DISTRIBUTION TRANSFORMERS**

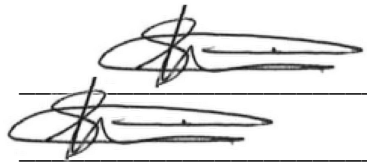
SPECIFICATION FOR THE SUPPLY, DELIVERY AND INSTALLATION OF DISTRIBUTION TRANSFORMERS


This specification covers Transnet Project's requirements for Distribution Transformers.

Author: S. Magcaba

Approved: S. Magcaba

Date: 24 July 2023



REVISIONS		
REV	DATE	APPROVED
0	11 April 2013	
01	05 May 2018	
02	24 July 2023	
02	11/11/2025	

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1. SCOPE

- 1.1 This specification covers Transnet's requirements for the design, supply, delivery and installation of single phase and three phase oil immersed type distribution and supply transformers for indoor and outdoor use. For this document Transnet Group Capital or Transnet Capital Projects shall be read as Transnet Port Terminals.

2. STANDARDS & SPECIFICATIONS

- 2.1 The following standards with latest amendments are referred to herein:

SOUTH AFRICAN STANDARDS

- SANS 064 - The preparation of steel surfaces for coating
- SANS 121 - Hot-dip Galvanised coatings for fabricated iron or steel articles
- SANS 555 - Unused and reclaimed mineral Insulating Oil for Transformers and Switchgear
- SANS 1019 - Standard voltages, currents and insulation levels for electrical supply
- SANS 1091 - National Colour Standard
- SANS 9001 - Quality management systems – requirements
- SANS 10111 - Engineering Drawings.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

BRITISH STANDARDS

- BS 171 - Power Transformers

- 2.2 Equipment offered shall comply with the latest editions of the relevant South African Bureau of Standards, British Standards or International Electro-technical Commission for Scientific and Industrial Research Publications and Reports.

- 2.3 Where equipment offered complies with the recognised standards of the country

of manufacture and not specifically with the standards required by this specification, such equipment will be considered at the discretion of Transnet Capital Projects. Tenderers shall however state the standards to which the equipment is manufactured and advise exactly how the equipment offered differs from the requirements of this specification.

- 2.4 Regardless of which specifications are actually worked to when manufacturing and supplying equipment, such equipment shall be capable of passing all tests laid down in the SABS or British Standards, or IEC specifications. Furthermore, Transnet Group Capital reserves the right to inspect any equipment at any stage during the contract period.

3. **METHOD OF TENDERING & COMPLIANCE**

- 3.1 Tenderers shall indicate clause by clause compliance with this specification. This shall take the form of a separate document listing all the specifications, clause numbers and indicating the individual statement of compliance or non-compliance.
- 3.2 The tenderer shall motivate a statement of non-compliance
- 3.3 Tenderers shall complete Appendix 2, 5 and 6“information to be provided by tenderers”
- 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 All Technical Data Sheets shall be signed by the Tenderer and returned.
- 3.6 All documents forming part of the Tender shall be firmly bound. No loose documents will be considered.
- 3.7 Failure to comply with the above requirements may preclude a tender from consideration.

4. **INFORMATION**

- 4.1 Tenderers shall specify their delivery period clearly.

4.2 Tenderers shall include a preliminary programme to illustrate their proposed schedule for manufacture and delivery. Tenderers must make due allowance for holidays such as the annual builders recess public holidays, weekends, etc.

5. **QUALITY CONTROL**

5.1 Tenderers must indicate what steps have been taken to implement a Quality Assurance System in terms of the ISO 9000 series of recommendations. The tenderer must submit a documented statement of their quality system with this tender which shall include the following:

- (i) Statement of quality management policy and objectives.
- (ii) Statement of the design control system with emphasis on design review procedures and customer requirements evaluation.
- (iii) Statement of the quality control procedure that will apply to erection on site.

5.2 The sole responsibility for ensuring that the components supplied conform to the specification shall rest with the Contractor.

5.3 Where tests are required on this equipment the Contractor shall provide such assistance, labour, materials, electricity, fuel, stores, apparatus and instruments as may be required to carry out tests efficiently. All gauges, templates, tools and other equipment required to check the accuracy of the work shall be calibrated at regular intervals by a laboratory approved by the National Calibration Services of the Council for Scientific and Industrial Research.

6. **ANNEXURES**

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

6.2 **Annexure 1 - "Schedule of Requirements".**

6.2.1 This appendix details specific requirements of the transformer.

6.3 **Annexure 2 - "Technical Data Sheet".**

- 6.3.1 This appendix calls for specific technical information to be furnished by tenderers and will be used for reference purposes by Transnet Capital Projects during adjudication. Failure to complete this appendix may preclude a tender from being considered.
- 6.3.2 All equipment detailed per this appendix shall be supplied in terms of this specification and no changes or substitutions will be allowed without the written consent of Transnet Capital Projects.
- 6.3.3 Acceptance by Transnet Capital Projects of the equipment detailed in this appendix, in no way relieves the tenderer of his obligation to fulfil his statement of compliance with this specification. The tenderer is responsible for the accuracy of information submitted in this appendix.
- 6.4 **Annexure 3 - "Technical Requirements for the Two (2) Gas Online Monitor"**
With a section/column which must be completed by all tenders and signed. Failure to do so may preclude a tender from being considered.
- 6.5 **Annexure 4 - "Technical Requirements for a Nine (9) Gas Online Monitor"**
With a section/column which must be completed by all tenders and signed. Failure to do so may preclude a tender from being considered.
- 6.6 **Annexure 5 - "Testing and Inspection Sheet".**
- 6.6.1 This provides details of requirements for the submission of test results for transformers not bearing the SABS standardisation mark and to be submitted in duplicate on completion of manufacture.
- 6.7 **Annexure 6 - "Statement of Compliance"**
Which must be completed by all tenders and signed. Failure to do so may preclude a tender from being considered.

7. SERVICE CONDITIONS

7.1 Ambient/Environmental Conditions

The equipment shall be designed and rated for continuous operation under the following conditions:-

Altitude	: 0 to 1800 above sea level
Ambient temperature	: -5 °C to +45 °C
Relative humidity	: As high as 95%
Lightning conditions	: Severe, with a maximum lightning ground flash density of 12 flashes per km ² per annum
Atmospheric conditions	: Salt laden as well as industrial pollution. Electrolytic corrosion conditions prevail in all areas owing to the proximity of direct current traction systems and cathodic protection schemes.

7.2 Electrical Supply Conditions

Electrical supply conditions will be as stated in Appendix No. 1. All equipment must however be capable of efficient operation under the following conditions:-

Voltage Variation	: ± 5% of nominal
Frequency	: 50 Hz ± 2 Hz
No of Phases	: Three phase system
Interference	: Severe switching surges and noise typical of a heavy industrial environment.
Waveform Distortion	: The low voltage windings in the transformers shall be subjected to harmonic distortion of up to 27%

8. DRAWINGS AND INSTRUCTIONS

8.1 All drawings shall be in accordance with SANS 10111 – Engineering Drawings.

8.2 Tenderers shall submit with their offers one print each of the following drawings:

- Drawing showing the arrangement of all fittings and terminal connections
- Drawing indicating the principal dimensions and mass
- Drawing indicating the details of the rating, diagram plates and vector diagram

- External wiring diagrams for the transformer
- 8.3 Three copies of each of the following drawings shall be submitted to the responsible project manager for approval within 7 days of the order being placed.
- Core & Core Details drawing.
 - Internal Construction Drawing
 - HV/LV Bushings indicating measurement of creepage distances.
 - Operation and Maintenance Manual.
- 8.3 Photocopies of original material will only be acceptable if these are clearly legible and preferably colour copies.
- 8.4 Operation and Maintenance manuals
- 8.4.1 The successful tenderer shall provide within 7 days of the order being placed, three copies of operational and maintenance manuals on all equipment provided to enable Transnet Capital Project's to maintain, service and repair the equipment. The manuals shall be provided in both hard copy and electronic format. (The electronic format must be in Microsoft "Word" or PDF format)

9. **GENERAL**

- 9.1 Unless specified the transformer shall be for outdoor use and the oil natural air natural (ONAN) cooled type) and shall comply with all relevant requirements of specifications IEC 60076-1 and BS 171.
- 9.2 All components used in the supply transformer shall be free from polychlorinated biphenyls (PCB free).

10. **TRANSFORMER TANK REQUIREMENTS**

- 10.1 The transformer tank shall be of welded construction type and shall be designed for the fitting of radiators.
- 10.2 The transformer tank shall be constructed of steel plate not less than 6mm thick.

- 10.3 The transformer breathing requirements are detailed in Annexure 1.
- 10.4 The transformer main tank cover joint shall be welded.
- 10.5 The welded joint of the main tank cover shall be designed to permit removal of the weld with the minimum damage to the mating flanges so that they will be suitable for re-welding.
- 10.6 The tank cover shall be fitted with suitable lifting lugs for the fitting or removal. Suitable pulling lugs shall also be provided to pull the transformer horizontally.
- 10.7 Inspection covers or manholes on the transformer tank shall be bolted and shall be provided with gasket seals. Sturdy handles shall be provided for removal of inspection or manhole covers.
- 10.8 Transformers shall be fitted with rollers,
- 10.9 Four jacking pads and lifting lugs shall be provided for the jacking and lifting the transformer complete with oil.
- 10.11 Provision shall be made for the fitting of filtration and main drain valves on the transformer tank.
- 10.12 Tenderers shall submit dimensioned drawings showing details of the transformer.

11. **TRANSFORMER FITTINGS REQUIRED**

11.1 **RADIATORS**

- 11.1.1 The transformer shall be fitted with detachable radiators with drain and filling plugs.
- 11.1.2 The design of the cooling radiators shall ensure sufficient circulation of cooling.
- 11.1.3 Provision shall be made for radiator shut off valves to allow the removal of the radiators without having to drain the oil from the transformer tank.
- 11.1.4 The radiators shall be provided with lifting lugs for fitting or removal.
- 11.1.5 The radiator shall be hot dipped galvanized.

11.2 CONSERVATOR TANK AND BREATHER

- 11.2.1 The transformer shall be fitted with a conservator tank with its oil level gauge and drain cock.
- 11.2.2 The connecting pipe to the conservator shall extend at least 50mm into it. All pipe connections shall have flange joints.
- 11.2.3 A silica gel dehydrating breather shall be provided with the conservator. Where specified in Appendix 1, a maintenance free dehydrating breather system shall be provided. The system shall be dehydrated by a sensor-controlled heater element.
- 11.2.4. Where specified in Appendix 1, the conservator shall be provided with a sealed oil preservation bag.
 - 11.2.4.1 The bag shall not restrict the normal draining of the conservator or the flow of oil to the transformer.
 - 11.2.4.2 The bag shall allow for expansion without any increase in pressure or the causing of a partial vacuum over the specified temperature range.
 - 11.2.4.3 Lifting lugs shall be fitted to the conservator.

11.3 OIL AND WINDING TEMPERATURE RELAYS

- 11.3.1 Provision shall be made for thermometer pockets on the transformer tank.
- 11.3.2 The transformer shall be fitted with a weatherproof dial type thermometer graduated in °C for registering “top oil” temperature. The instrument shall be fitted with a resettable maximum temperature indicator.
 - 11.3.2.1 Adjustable contacts shall be fitted to the thermometer. The contacts shall normally be set to operate at a temperature of 90°C. The trip contacts shall be liberally rated and adequate for closing 110 volt, 6 Ampere DC circuits. If not suitable, auxiliary relays shall be provided.
- 11.3.3 A thermal type overload relay to protect the transformer windings against sustained overloads. This relay shall have a load-temperature characteristic approximately the same as the transformer winding hot spot. Suitable means for compensation for variation of ambient air temperature shall be provided.

- 11.3.3.1 The relay shall be provided with trip contacts. The tenderer is to recommend the temperature setting for these contacts which are normally set at 115 °C. The trip contacts shall be liberally rated and adequate for closing 110 volt, 6 Ampere DC circuits. If not suitable, auxiliary relays shall be provided.
- 11.3.3.1 Transformers from 10MVA and above must be fitted with RTDs to measure the exact temperature of the windings.

11.4 **ONLINE DISSOLVED GAS MONITOR**

11.4.1 **Scope**

This section details the requirements for an online dissolved gas monitor for power transformers.

11.4.2 **General**

- 11.4.2.1 Two types of online dissolved gas monitor shall be offered which are as follows:
- a) A nine (9) gas including moisture online dissolved gas monitor shall be installed on transformer 10MVA and greater; and
 - b) A two (2) gas including moisture online dissolved gas monitor shall be installed on transformer greater than 1MVA.
 - c) Where the TRF is less than 1MVA and supplying critical loads, e.g. petrochemical services, national key point security lighting, etc. The online dissolved gas monitoring system for two gases shall be installed. This is to say all TRFs for this project shall have this technology.
- 11.4.2.2 The online dissolved gas monitor shall have a built-in oil circulation and flow monitoring.
- 11.4.2.3 The online dissolved gas monitor shall be vacuum tolerant.
- 11.4.2.4 The online dissolved gas monitor shall be field robust and proven to operate in harsh environmental conditions. Tenderers shall submit proof of such installations.
- 11.4.2.5 The online dissolved gas monitor housing shall be stainless steel grade 304 and lockable.
- 11.4.2.6 The online dissolved gas monitor shall have an expected operating life of greater than 15 years.
- 11.4.2.7 All oil line shall be of stainless-steel braided flex type.
- 11.4.2.8 The online dissolved gas monitor shall have a 30-month standard warranty.
- 11.4.2.9 The online dissolved gas monitor shall be so designed to prevent the introduction of bubbles entering the transformer.

11.4.3 Standards

The online dissolved gas monitor shall comply with the following international standards:

- a) EMC (Electromagnetic Compatibility) IEC 61326, IEC 61000-6-5 and IEC 61850-3
- b) Electrical safety IEC 61010 and IEC 60255-27

11.4.4 Operating Conditions

11.4.4.1 The online dissolved gas monitor shall be exposed to high levels of population and shall have an ingress protection of IP56.

11.4.4.2 All communications shall have substation-hardened electronics and isolation rated for substation environments.

11.4.4.3 The online dissolved gas monitor shall withstand the following without decreasing performance, reducing reliability and limiting life:

- a) Operating temperature range of -10 to 55oC;
- b) Operating oil temperature range of -10 to +120 oC;
- c) Operating humidity range of 0 - 100% RH; and
- d) Altitude range up to 3 500 m.

11.4.5 Two (2) Gas Online Monitor

11.4.5.1 The tenderer shall supply a two (2) gas online monitor which shall include moisture in oil and insulation measurements.

11.4.5.2 The measured gases and moisture together with the detection range, accuracy and repeatability shall comply with Table 1.

Table 1: Measurement Parameters

Measurement	Detection Range	Accuracy	Repeatability
Hydrogen (H ₂)	2 - 50,000 ppm	±5%	±3%
Carbon Monoxide (CO)	25 - 100,000 ppm	±15%	±10%
Moisture in oil	2 ppm - saturation	+3 ppm	+2 ppm
Moisture in insulation	2 - 100% RS	+3%	+2%

- 11.4.5.3 The front panel shall incorporate a digital display and a local USB 2 port.
- 11.4.5.4 All other buttons shall be UV-resistant.
- 11.4.5.5 No calibration shall be required for the life of the online dissolved gas monitor.
- 11.4.5.6 The online dissolved gas monitor shall be supplied with the following permanent connections:
 - a) RS-485 port (1,500 V isolation);
 - b) RS-232 port (1,500 V isolation);
 - c) Two (2) Ethernet ports (1,500 V isolation);
 - d) Three (3) analogy outputs for H₂, CO and H₂O, 4-20 mA (1,500 V isolation); and
 - e) Oil temperature analogy input, 4-20 mA (1,500 V isolation).
- 11.4.5.7 The online dissolved gas monitor shall be supplied with the following communication options:
 - a) Modbus;
 - b) DNP3 Level 2;
 - c) IEC 61850; and
 - d) Time Synchronization: SNTP.
- 11.4.5.8 The alarms shall be programmable dual-level and trend alarms for H₂, CO and H₂O.
- 11.4.5.9 Data storage shall be for a minimum of 1 year.
- 11.4.6 **Nine (9) Gas Online Monitor**
 - 11.4.6.1 The tenderer shall supply a nine (9) gas online monitor which shall include moisture in oil and insulation measurements.
 - 11.4.6.2 The measured gases and moisture together with the detection range, accuracy and repeatability shall comply with Table 2 and Table 3.

Table 2: Gas Parameters

Gas	H ₂	CO	CH ₄	C ₂ H ₂	C ₂ H ₄	C ₂ H ₆	CO ₂	O ₂	N ₂
Detection range (ppm)	0.5 - 20,000	10 - 30,000	0.2 - 100,000	0.2 - 100,000	0.2 - 200,000	0.2 - 200,000	15 - 100,000	500 - 100,000	2000 - 150,000
Accuracy (%)	5	5	5	5	6	5	15	15	15
Repeatability (%)	3	3	3	3	4	3	10	10	10

Table 3: Moisture Parameters

Moisture	Moisture in oil	Moisture in insulation
Detection range (ppm)	2 ppm - Saturation	2% - 100% of RS
Accuracy (%)	±3 ppm	±3% of RS
Repeatability (%)	±2 ppm	±2% of RS

- 11.4.6.3 The gas measurement shall be performed by a chromatographic method.
- 11.4.6.4 The gas chromatography columns shall have a minimum service life of 10 years.
- 11.4.6.5 All gases shall be measured independently and no mathematical calculation for gas measurements shall be accepted.
- 11.4.6.6 A non-mechanical extraction system to remove gases dissolved in oil shall be used.
- 11.4.6.7 Oil temperature conditioning shall be used to improve accuracy.
- 11.4.6.8 The internal temperature shall be controlled to a maximum of 350C to improve long term reliability of electronic components in hot climates.
- 11.4.6.9 Calibration shall be automatic and user configurable at 24 or 48 or 72 hour intervals.
- 11.4.6.10 The calibration and carrier gas shall have a minimum of 4 years before being replaced.
- 11.4.6.11 The sampling interval for all gases shall be 3, 2 and 1hour. This shall be user configurable.
- 11.4.6.12 Moisture measurements shall be performed every 6 seconds.
- 11.4.6.13 Data storage shall be for a minimum of 6 years.
- 11.4.6.14 The front panel interface shall incorporate a digital display and a local USB 2 port.
- 11.4.6.15 All other buttons shall be UV-resistant.
- 11.4.6.16 The front panel interface shall be menu driven for all function such as measurements, alarms, maintenance etc.
- 11.4.6.17 The online monitoring system shall be supplied with the following communication options:
- a) Modbus;
 - b) DNP3 Level 2;
 - c) IEC 61850; and
 - d) Time Synchronization: SNTP.
- 11.4.6.18 The online monitoring system shall be supplied with the following permanent connections:
- a) RS-485, RS-232, Ethernet (5 kV impulse, 2.6 kVac);
 - b) 10 assignable 4-20 mA outputs (5 kV impulse, 2.6 kVac);

- c) 3 assignable 4-20 mA inputs (5 kV impulse, 2.6 kVac); and
- d) 10 NO/NC relay outputs contacts assignable for set-up, self-test and measurement alarm conditions (250VAC, 5A; 48VDC, 1.5A)

11.4.6.19 The alarms shall be programmable dual-level and trend alarms for all gases. The applicable relays shall be fitted with accessible test and sample valves.

11.4.6.20 The instrument shall be self-diagnostic with error codes with intuitive descriptions and recommended client actions.

11.4.7 **Software**

11.4.7.1 All settings, configurations, diagnostics, firmware upgrades and reporting shall be performed using dedicated software.

11.4.7.2 The software shall also include a database for the measurements.

11.4.7.3 The software shall be able manage a fleet of online line DGA systems irrespective of the number of gases been measured.

11.4.7.4 The software shall display gases in graphical format and allow the user to export the data in a csv format.

11.4.7.5 Alarm limits in ppm shall be as per IEC 60599.

11.4.8 **Training**

11.4.8.1 Training shall be provided to 5 staff.

11.4.8.2 The training shall cover theory of dissolved gas analysis, measurement method, installation, software, maintenance and trouble shooting.

11.4.9 **Support**

11.4.9.1 Technical and commercial support shall be located in South Africa.

11.4.9.2 The response for support shall be within 12 hours.

11.5 **PRESSURE RELIEF DEVICE**

11.5.1 A suitable pressure relief device shall be fitted on the main tank if it is considered necessary by the manufacturer. The provision of the pressure relief device shall not affect the efficiency of the Buchholz relay in the event of a transformer fault.

11.6 **MARSHALLING BOX**

- 11.6.1 A marshalling box shall be fitted to the transformer tank. The degree of protection shall be IP55 and shall be hot dipped galvanised.
- 11.6.2 All terminals in the marshaling box shall be clearly labelled.

11.7 **GAS AND OIL OPERATED RELAY (BUCHOLZ)**

- 11.7.1 A single-float Buchholz relay fitted with contacts for alarm and trip conditions shall be provided.
- 11.7.2 The relay shall be fitted with accessible test and sample valves.

12. **TERMINALS AND BUSHINGS**

- 12.1 All terminals shall be extended to the top of the transformer tank through suitable outdoor type bushings.
- 12.2 These bushings shall conform to the insulation levels as specified in IEC 60137 for the system nominal supply voltage at which the equipment must operate.
- 12.3 All bushing, stems and terminals shall be of sufficient size to ensure sufficient mechanical strength of attaching and supporting external connections and shall not be smaller than:
 - a) 19mm diameter for primary and secondary connections
 - b) 12mm diameter for auxiliary supply connections
- 12.4 Where cable boxes are required, bushings shall be provided for the termination of the cables in the cable box.
- 12.5 Provision shall be made for earthing terminals fitted on the outside of the transformer tank for the connection of a 95mm².

13. **TRANSFORMER WINDINGS**

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

13.2 Tenderers shall submit details of the construction of the windings and the clamping arrangements at tender.

14. **TEMPERATURE RISE AND RATING**

14.1 The temperature rise of the transformer windings after thermal equilibrium and steady temperature has been reached on continuous full load, shall not exceed 65°C.

14.2 The temperature rise windings shall be measured by the increase of resistance method. Standard correction cooling during the measurement of resistance shall be applied.

15. **VOLTAGE RATIO AND TAPPINGS**

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

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

15.3 The tap range shall be $\pm 2.5\%$ and $\pm 5\%$ of the nominal voltages.

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

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

15.6 The tap changing gear shall be either manually operated or automated as detailed in the Annexures.

15.7 Where manually operated type tap changing is specified, the gear shall be externally operated, positively locking, offload type. The arrangement shall be such that excessive backlash will not affect the making of the proper contact when the tap changing gear is operated in either direction. Rotary type having high pressure type contacts is preferred.

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

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

16. INSULATION LEVELS

- 16.1 Transformer bushings shall comply with IEC 60137.
- 16.2 Test voltage and minimum creepage distances for normal and polluted atmospheres shall be in accordance with IEC 60137.

17. CORROSION PROTECTION AND PAINTING

17.1 PREPARATION OF ALL METAL SURFACES

- 17.1.1 All metal surfaces shall be prepared for corrosion-proofing and painting in accordance with the practice recommended in SANS 064.
- 17.1.2 Rust and milliscale shall be removed by shot blasting acid cleaning. Welds which are not ground smooth shall be shot blasted or otherwise descaled and cleaned.

17.2 PAINTING

17.2.1 Internal Surfaces

17.2.1.1 Surfaces normally below cooling liquid level

- 17.2.1.2 After cleaning with an approved abrasive or pickling process, interior surfaces, above a margin 100mm below the minimum cold liquid level shall be temporarily protected by means of oiling until it is filled with the cooling liquid. Alternatively, these surfaces may be permanently protected by means of an approved varnish or light coloured priming or paint coating which is unaffected by the cooling liquid up to 120°C.

17.2.2 Surfaces of liquid-filled compartments above liquid level

- 17.2.2.1 Interior surfaces to a margin 100mm below the minimum cold liquid level shall be protected by means of an approved oil resistant rust inhibiting etch primer.

17.2.3 Terminal-boxes, Marshalling-boxes and Control cubicles

- 17.2.3.1 Interior surfaces shall be given an approved corrosion-proofing treatment, and finishing white gloss enamel.

17.2.4 External surfaces

- 17.2.4.1 The total paint thickness on all external surfaces (including radiators) shall be at least 75 microns. For coastal or heavily polluted conditions it shall be at least 125 microns. All external surfaces shall be finished with an acceptable out coat colour to match colour detailed in Annexure 4.
- 17.2.4.2 The outer surface of the transformer tank shall be painted Grey to the colour code G12 in accordance to SANS 1091. The conservator shall be painted white.

18. TRANSFORMER OIL

- 18.1 The tendered price shall include the first filling of oil. The oil shall comply with SANS 555.
- 18.2 The oil shall be readily miscible with oil supplied in conformity with the above mentioned specification by the major oil companies in South Africa, without detriment to the chemical, physical and electrical properties of the oil.
- 18.3 Liquids of the poly-chlorinated-biphenyl (PCB) types shall not be used

19. RATING PLATE

- 19.1 A non-corrosive metal plate shall be fixed to each transformer tank (not cooling tubes), giving the following information:
- Makers name
 - Makers serial No.
 - Transnet's serial No. (Left blank)
 - Rated output in MVA
 - Frequency
 - Secondary voltage and current
 - Primary voltage and current
 - Primary voltage tapplings
 - Transformer reactance (%)
 - Transformer impedance (%)
 - Vector diagram
 - Diagram of connections
 - Quantity of oil in liters
 - Conservator fitted with bag

- Total mass of transformer inclusive of oil in kg
- Transport mass of transformer in kg
- Year of manufacture

19.2 Labels shall be fixed by screws or rivets.

19.3 All labels shall be made of composite sandwich type plastic material with black lettering on white background. Letters must be of sufficient size to be clearly legible.

20. TESTS

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

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

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

20.4 Transnet Capital Projects must be notified timeously for routine or impulse test to be witnessed.

21. INSPECTION

21.1 Transnet Capital Projects reserves the right, to be present during construction and testing and must be timeously advised of the dates of commencement of construction and of testing.

22. PACKING

22.1 The transformers shall be crated, packed or loaded in such a manner that they shall not sustain damage during handling and transport, and precautions shall be taken to ensure that moisture cannot enter the transformer.

23. GUARANTEE AND DEFECTS

Technical Specification
Specification No. TCPELE014TRANSFORMER

- 23.1 The contractor shall guarantee the transformer and accept liability for maker's defects, which may appear in design, materials and workmanship.
- 23.2 The guarantee period for the transformer shall expire after a period of 12 months commencing on the date of commissioning of the equipment.

ANNEXURE 1.

"SCHEDULE OF REQUIREMENTS FOR TRF"

1. GENERAL

1.1 Item No. _____ Order No. _____

1.2 Required for _____

1.3 Date of delivery of equipment to site : _____

2. DETAILS OF SUPPLY SYSTEM

2.1 Voltage: _____
No. of Phases _____ Frequency **50 Hz**

2.2 Neutral: Effectively earthed _____X
Impedance earthed _____

3. DETAILS OF TRANSFORMER

3.1 Type 1 (22kV/11kV) , Quantity required _____ RATED
Connected System: **DNY11**

3.2 Double wound _____X

Auto Transformer _____

3.3 High loss _____

Low loss _____X

3.4 Type of cooling: Oil _____X

Air _____X

Synthetic _____

Dry type _____

3.5 Tap changing: Manual _____

Automated _____X

3.5 Nature of load
• Type 1 :

- 3.6 Transformers are required to operate in parallel with the following existing transformer.N/A
- 3.6.1 Rated power ____ N/A _____ KVA Vector symbol ____ N/A_____
- 3.6.2 Turns ratio of windings at rated voltage _____ N/A_____
- 3.6.3 Turns ratio corresponding to the tapings _____ N/A_____
- 3.6.4 Tappings on High voltage winding _____ N/A_____
- 3.6.4 Tappings on Low voltage winding _____
- 3.6.5 Impedance voltage on principal tapping _____ N/A_____
- 3.6.6 Load loss at rated current _____ N/A_____

4. HIGHER VOLTAGE WINDING

- 4.1 **Primary**
- 4.2 Rate Voltage (at No-load) .Number of phases
- 4.3 Terminals details:
 - 4.3.1 Cable box _____
 - Bushings _____ X
 - Disconnecting chamber _____
- 4.4 Size of cable
Number of cores
- 4.4.1 Type of cable **XLPE copper cable**
- 4.5 Neutral point bushing:

5.1 LOWER VOLTAGE WINDING -TYPE 1

5.1.1 Secondary

5.1.2 Rate Voltage (at No load):
Number of PHASES: **3**

5.1.3 Terminal details:

5.1.3.1 Cable box _____
Bushings _____ X
Disconnecting chamber

5.1.4 Size and quantity of busbar **To be determined by contractor**

5.1.5 Neutral point bushing:

6. DETAILS OF CONSTRUCTIONS

6.1 Indoor/Outdoor: **Indoor**

6.2 Free breathing: 500 KVA and above (Reqd/Not reqd)

6.3 Dehydrating Breather (Standard type): 500 KVA and above (Reqd/Not reqd)

6.4 Dehydrating Breather (Maintenance free type): 500 KVA and above (Reqd/Not reqd) **Required**

6.5 Sealed. Below 500 KVA (Reqd/Not reqd)

6.6 Mounting requirements.

6.6.1 Pole clamps: _____
Pole-platform or floor **Floor**

6.6.2 Axles and wheels: _____ X
Skid base _____
Flat base _____

6.7 Jacking pads (Reqd/Not reqd) **Required**

6.8 Lashing lugs (Reqd/Not reqd) **Required**

6.9 Current transformer (Ratio):
Bushing type _____
Tank type _____

6.10 Conservator tank **Required**

5. **ADDITIONAL REQUIREMENTS FOR TRANSFORMERS 500KVA AND ABOVE**

7.1 Gas and oil actuated relay: **Two** pair. Tripping contacts

7.2 Alarm contacts: **Two** pair. Tripping contacts

7.3 Tripping contact: **Two** pair.

6. **TESTS**

8.1 Impulse tests (Reqd/Not reqd): **Required**

8.2 Temperature Rise test (Reqd/Not reqd): **Required**

9. **SPECIAL REQUIREMENTS**

9.1 All transformers of the same voltage rating to be suitable for parallel operations.

9.2 Transformers shall be placed inside a room with the dimensions as shown in the plan layout drawing:

9.3 Access is via a roller shutter door

"SCHEDULE OF REQUIREMENTS FOR 1000kVA and below TRF"

2. GENERAL

- 1.1 Item No. _____ Order No. _____
- 1.2 Required for _____
- 1.3 Date of delivery of equipment to site : _____

5. DETAILS OF SUPPLY SYSTEM

- 2.1 Voltage:
No. of Phases _____ Frequency **50 Hz**
- 2.2 Neutral: Effectively earthed _____X
Impedance earthed _____

6. DETAILS OF TRANSFORMER

- 3.1 Type 1 (630kV/400V) , Quantity required **2** RATED
Connected System: **DNY11**
- 3.2 Double wound _____X
Auto Transformer _____
- 3.3 High loss _____
Low loss _____X
- 3.4 Type of cooling: Oil _____X
Air _____X
Synthetic _____
Dry type _____
- 3.5 Tap changing: Manual _____
Automated _____X
- 6.5 Nature of load
 - Type 1 (11kV/400V) : **(General, Lighting, Hand tools, etc)**

- 3.6 Transformers are required to operate in parallel with the following existing transformer.N/A
- 3.6.1 Rated power ____ N/A _____ KVA Vector symbol ____ N/A_____
- 3.6.2 Turns ratio of windings at rated voltage _____ N/A_____
- 3.6.3 Turns ratio corresponding to the tapings _____ N/A_____
- 3.6.4 Tappings on High voltage winding _____ N/A_____
- 3.6.4 Tappings on Low voltage winding _____
- 3.6.5 Impedance voltage on principal tapping _____ N/A_____
- 3.6.6 Load loss at rated current _____ N/A_____

7. PRIMARY WINDING

- 4.1 **Primary**
- 4.2 Rate Voltage (at No-load) **11kV** .Number of phases **3**
- 4.3 Terminals details:
 - 4.3.1 Cable box _____ X
 - Bushings _____
 - Disconnecting chamber _____
- 4.4 Size of cable
Number of cores **3**
- 4.4.1 Type of cable **XLPE copper cable**
- 4.5 Neutral point bushing: **Not Required**

5.2 LOWER VOLTAGE WINDING -TYPE 1 (11kV/400V)

- 5.1.1 **Secondary**
- 5.1.2 Rate Voltage (at No load): **400V**
Number of PHASES: **3**
- 5.1.3 Terminal details:
 - 5.1.3.1 Cable box _____
Bushings _____ X
Disconnecting chamber
- 5.1.4 Size and quantity of busbar **To be determined by contractor**
- 5.1.6 Neutral point bushing: **Not Required**

7. DETAILS OF CONSTRUCTIONS

- 6.1 Indoor/Outdoor: **Indoor**
- 6.2 Free breathing: 500 KVA and above (Reqd/Not reqd) **Required**
- 6.3 Dehydrating Breather (Standard type): 500 KVA and above (Reqd/Not reqd)
- 6.4 Dehydrating Breather (Maintenance free type): 500 KVA and above (Reqd/Not reqd)
- 6.5 Sealed. Below 500 KVA (Reqd/Not reqd)
- 6.6 Mounting requirements.
 - 6.6.1 Pole clamps: _____
Pole-platform or floor **Floor**
 - 6.6.2 Axles and wheels: _____ X
Skid base _____
Flat base _____
- 6.7 Jacking pads (Reqd/Not reqd) **Required**
- 6.8 Lashing lugs (Reqd/Not reqd) **Required**

6.9 Current transformer (Ratio):
Bushing type _____
Tank type _____

6.10 Conservator tank **Required**

7. **ADDITIONAL REQUIREMENTS FOR TRANSFORMERS 500KVA AND ABOVE**

7.1 Gas and oil actuated relay: **Two** pair. Tripping contacts

7.2 Alarm contacts: **Two** pair. Tripping contacts

7.3 Tripping contact: **Two** pair.

8. **TESTS**

8.1 Impulse tests (Reqd/Not reqd): **Required**

8.2 Temperature Rise test (Reqd/Not reqd): **Required**

9. **SPECIAL REQUIREMENTS**

9.1 All transformers of the same voltage rating to be suitable for parallel operations.

9.3 Transformers shall be placed inside a room with the dimensions as shown in the plan layout drawing:

9.3 Access is via a roller shutter door (**See substation drawings for dimension details**).

ANNEXURE 2

"TECHNICAL DATA SHEET"

(To be filled in by Tenderer)

1. Tender No. _____ Item No. _____
2. Manufacturers name _____
3. DETAILS OF CONDUCTING MATERIAL

	Higher voltage Winding	Lower voltage Winding
Type		
Copper and /or aluminium		
Mass of Conductor (kg)		

4. Adjustable axial coils provided YES..... NO.....
5. High voltage end turns insulation reinforced YES..... NO.....
6. Mass of transformer complete with oil _____ kg.
7. Quantity of oil required _____ (Litres)
8. Noise level (Dry type transformers) _____
9. Synthetic liquid immersed transformers:
 - 9.1 Free breathing YES..... ..NO.....
 - Hermetically sealed YES..... NO.....
 - 9.2 Type of breather and dehydrating agent _____



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- 9.3 If free breathing state details of arrangement to prevent deterioration of volatile fractions

10. The following information refers to the transformer when connected on the principal tapping and appropriate reference temperature for the class of insulation used.
- 10.1 Iron loss (watts) _____
- 10.2 Copper loss at full load _____ at _____ °C
- 10.3 Total load losses (watts) _____ at _____ °C
- 10.4 Impedance at full load (%) _____ Z _____ X _____ R at _____ °C
- 10.5 Regulation at full load at: 1,0 pf _____ % 0,8 pf _____ % at _____ °C
- 10.6 Efficiency at full load at: 1,0 pf _____ % 0,8 pf _____ % at _____ °C
11. Standard to which transformer is manufactured if other than that mentioned in this specification

SIGNATURE OF TENDERER _____

DATE _____

NAME AND ADDRESS OF TENDERER _____

ANNEXURE 3

TECHNICAL REQUIREMENTS FOR THE TWO (2) GAS ONLINE MONITOR

Item	Description	Requirement	Offer
1.0	OEM details		
1.1	Name of Manufacture		
1.2	Model		
1.3	Country Manufactured		
2.0	Operating Condition		
2.1	Installation	Indoor and Outdoor	
2.2	Ambient temperature	-10 to 55°C	
2.3	Oil temperature	-10 to +120°C	
2.4	Humidity	0 - 100% RH	
2.5	Altitude	up to 3 500 m	
2.6	Voltage and frequency	230V @ 50Hz	
3.0	General Design Requirements		
3.1	Housing	stainless steel grade 304	
3.2	IP rating	IP56	
3.3	Oil circulation and flow monitoring	Yes	
3.4	Vacuum tolerant	Yes - 40 psi	Yes/No
3.5	Oil lines	Stainless steel braided flex type.	
3.6	Expected operating life	>15 years	
3.7	Standard warranty	30 months	
3.8	Bubble prevention	Yes	Yes/No
3.9	Calibration for life of system	None	
3.10	Front panel	Digital display and USB 2 port	
4.0	Communication Ports, IO Ports and Data		
4.1	RS-485 port	One (1) (1,500 V isolation)	
4.2	RS-232 port	One (1) (1,500 V isolation)	
4.3	Ethernet ports	Two (2) (1,500 V isolation)	
4.4	4-20 mA analogy outputs for H ₂ , CO and H ₂ O	Three (3) (1,500 V isolation)	
4.5	4-20 mA analogy input for oil temperature	One (1) (1,500 V isolation)	

4.6	Measurement alarms	Programmable dual-level and trend alarms for H ₂ , CO and H ₂ O	
4.7	Alarm relays	5 NO/NC contacts (250VAC, 5A; 48VDC, 1.5A)	
4.8	Data storage	minimum of 1 years	
5.0	Communication Protocols		
5.1	Modbus	Yes	Yes/No
5.2	DNP3 Level 2	Yes	Yes/No
5.3	IEC 61850	Yes	Yes/No
5.4	Time Synchronization: SNTP	Yes	Yes/No
Item	Description	Requirement	Offer
6.0	Continuous Detection		
6.1	Gas detection	H ₂ and CO	
6.2	Moisture detection	Moisture in oil	
6.3	Hydrogen (H ₂)		
6.3.1	<i>Detection Range</i>	2 - 50,000 ppm	
6.3.2	<i>Accuracy</i>	±5%	
6.3.3	<i>Repeatability</i>	±3%	
6.4	Carbon Monoxide (CO)		
6.4.1	<i>Detection Range</i>	25 - 100,000 ppm	
6.4.2	<i>Accuracy</i>	±15%	
6.4.3	<i>Repeatability</i>	±10%	
6.5	Moisture in oil		
6.5.1	<i>Detection Range</i>	2 ppm - saturation	
6.5.2	<i>Accuracy</i>	+ 3 ppm	
6.5.3	<i>Repeatability</i>	+ 2 ppm	
6.6	Moisture in insulation		
6.6.1	<i>Detection Range</i>	2 - 100% RS	
6.6.2	<i>Accuracy</i>	+ 3%	
6.6.3	<i>Repeatability</i>	+ 2%	
7.0	Compliance to International standards		
7.1	Electromagnetic Compatibility	IEC/EN 61326	
		IEC/EN 61000-6-5	
		IEC/EN 61850-3	
7.2	Electrical safety	IEC/EN 61010	
		IEC/EN 60255-27	
7.3	Mechanical	IEC 60255-21-1 Class 1 (Vibration)	
		IEC 60068-2-27 (Shock)	
		IEC 60255-21-3 (Seismic)	
7.4	Quality Management	ISO 9001	



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8.0	Software		
8.1	Name of software		
8.2	Includes a database	Yes	Yes/No
8.3	Manage multiple units	Yes	Yes/No
8.4	Graphical representation	Yes	Yes/No
8.5	Exported in csv format	Yes	Yes/No
8.6	Alarm limits as per IEC 60599	Yes	Yes/No
9.0	Training		
9.1	Number of staff	5	
9.2	Trainings courses covers	Measurement method	Yes/No
		Installation	Yes/No
		Software	Yes/No
		Maintenance	Yes/No
		Trouble Shooting	Yes/No
10.0	Support		
10.1	After sales support	Technical and commercial	Yes/No
10.2	Location	South Africa	Yes/No
10.3	Response time	12 hours	

SIGNATURE OF TENDERER _____

DATE _____

NAME AND ADDRESS OF TENDERER _____

ANNEXURE 4

TECHNICAL REQUIREMENTS FOR THE NINE (9) GAS ONLINE MONITOR

Item	Description	Requirement	Offer
4.7	Alarm relays	10 NO/NC contacts (250VAC, 5A; 48VDC, 1.5A)	
4.8	Data storage	minimum of 6 years	
5.0	Communication Protocols		
5.1	Modbus	Yes	Yes/No
5.2	DNP3 Level 2	Yes	Yes/No
5.3	IEC 61850	Yes	Yes/No
5.4	Time Synchronization: SNTP	Yes	Yes/No
6.0	Continuous Detection		
6.1	Hydrogen (H₂)		
6.1.1	Detection Range (ppm)	0.5 -20,000	
6.1.2	Accuracy (%)	5	
6.1.3	Repeatability (%)	3	
6.2	Carbon Monoxide (CO)		
6.2.1	Detection Range (ppm)	10 -30,000	
6.2.2	Accuracy (%)	5	
6.2.3	Repeatability (%)	3	
6.3	Methane (CH₄)		
6.3.1	Detection Range (ppm)	0.2 - 100,000	
6.3.2	Accuracy (%)	5	
6.3.3	Repeatability (%)	3	
6.4	Acetylene (C₂H₂)		
6.4.1	Detection Range (ppm)	0.2 - 100,000	
6.4.2	Accuracy (%)	5	
6.4.3	Repeatability (%)	3	
6.5	Ethylene (C₂H₄)		
6.5.1	Detection Range (ppm)	0.2 - 200,000	
6.5.2	Accuracy (%)	6	
6.5.3	Repeatability (%)	4	
6.6	Ethane (C₂H₆)		
6.6.1	Detection Range (ppm)	0.2 - 200,000	
6.6.2	Accuracy (%)	5	
6.6.3	Repeatability (%)	3	
6.7	Carbon dioxide (CO₂)		
6.7.1	Detection Range (ppm)	15 -100,000	

6.7.2	Accuracy (%)	15	
6.7.3	Repeatability (%)	10	
6.8	Oxygen (O₂)		
6.8.1	Detection Range (ppm)	500 - 100,000	
6.8.2	Accuracy (%)	15	
6.8.3	Repeatability (%)	10	
6.9	Nitrogen (N₂)		
6.9.1	Detection Range (ppm)	2000 - 150,000	
6.9.1	Accuracy (%)	15	
6.9.2	Repeatability (%)	10	
6.10	Moisture in oil		
6.10.1	Detection Range	2 ppm - Saturation	
6.10.2	Accuracy	±3 ppm	
6.10.3	Repeatability	±2 ppm	
6.11	Moisture in insulation		
6.11.1	Detection Range	2% - 100% of RS	
6.11.2	Accuracy	±3% of RS	
6.11.3	Repeatability	±2% of RS	
7.0	Compliance to International standards		
7.1	Electromagnetic Compatibility	IEC/EN 61326	
		IEC/EN 61000-6-5	
		IEC/EN 61850-3	
7.2	Electrical safety	IEC/EN 61010	
		IEC/EN 60255-27	
7.3	Quality Management	ISO 9001	
8.0	Software		
8.1	Name of software		
8.2	Includes a database	Yes	Yes/No
8.3	Manage multiple units	Yes	Yes/No
8.4	Graphical representation	Yes	Yes/No
8.5	Exported in csv format	Yes	Yes/No
8.6	Alarm limits as per IEC 60599	Yes	Yes/No
8.0	Training		
8.1	No of staff	5	
8.2	Trainings courses covers	Theory and Measurement methods	Yes/No
		Installation	Yes/No
		Software	Yes/No
		Maintenance	Yes/No
		Trouble Shooting	Yes/No
9.0	Support		



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9.1	After sales support	Technical and commercial	Yes/No
9.2	Location	South Africa	Yes/No
9.3	Response time	12 hours	

SIGNATURE OF TENDERER _____

DATE _____

NAME AND ADDRESS OF TENDERER _____

ANNEXURE 5

ROUTINE TESTING AND INSPECTION OF POWER TRANSFORMERS NOT BEARING THE SABS STANDARDIZATION MARK

NAME PLATE DATA

Serial No	:	_____
Phase	:	_____
kVA	:	_____
Cooling	:	_____
Volts HV	:	_____
Total mass	:	_____
(No Load)-LV	:	_____
Class	:	_____
Vector group	:	_____
Amps HV	:	_____
Impedance	:	_____
(Full Load)-LV	:	_____
Diagram No.	:	_____

INSPECTION DATA

Manufacturer	:	_____
Inspection Request No.	:	_____
Order No.	:	_____
Date	:	_____



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1. MEASUREMENT OF WINDING RESISTANCE

TEST METHOD _____

HIGH VOLTAGE WINDINGS			RESISTANCE		LOW VOLTAGE WINDINGS			RESISTANCE
Terminals	Amps x	Volts x	Term x	Phase	Terminals	Amps x	Volts x	Term x Phase x
At _____ °C =					At _____ °C =			
At 75°C =					At 75°C =			
I. ² R. Loss at 75°C =					I. ² R. Loss at 75°C =			

Total I.² R. Loss at 75°C = _____ + _____ = _____

2 RATIO _____ TEST METHOD _____

		TAP					
HV	LV	1	2	3	4	5	6
+ -	+ -	Meas.	Meas.	Meas.	Meas.	Meas.	Meas.
Calculated							

Terminals : _____ Tap : _____ Maximum Error : _____



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3. **LOAD LOSSES** TEST METHOD _____

Temperature _____ °C

		WATTS				
VOLTS X	AMPS X	W ₁ X	W ₂ X	W ₃ X	W ₁ X + W ₂ X + W ₃ X INSTR.	I ² R. + Stray at 75°C

I²R. Loss at 75°C from 1. above =

Stray Loss x T.C.F.² =

Stray Loss x 75°C. =

Total load loss at 75°C = I²R. Loss at 75°C + Stray Loss at 75°C

= _____ + _____ = _____ watts

4. **NO LOAD LOSSES**

VOLTS X	AMPS X	W ₁ X	W ₂ X	W ₃ X	W ₁ X + W ₂ X + W ₃ X	INSTR.	LOSSES

Total Losses at Full Load = Total Load Losses + Fe Loss

= _____ + _____ = _____ watts

5. **INSULATION RESISTANCE**

HV - Earth = _____ megohms

Technical Specification
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HV - Earth = _____ megohms

LV - Earth = _____ megohms

Tertiary - Earth = _____ megohms

Oil _____ = kV for one minute.

U.B.D. Value _____ kV.

6. INDUCED OVERVOLTAGE WITHSTAND

Test Frequency _____ C.P.S.

Applied HV/LV _____ volts

Time _____ seconds

7. SEPARATE SOURCE WITHSTAND

HT to LT + E = _____ kV for one minute

LT to HT + E = _____ kV for one minute

Tertiary to HT - LT + E = _____ kV for one minute

CALCULATIONS : AT FULL LOAD AND UNITY POWER FACTOR

$$\%Z_t^2 = \left(\frac{\text{S.C. volts at F.L. current} \times 100}{\text{O.C. volts}} \right)^2 = \underline{\hspace{2cm}}$$

$$\%R_t^2 = \left(\frac{\text{S.C.watts (cold) at F.L. current}}{\text{kVA} \times 10} \right)^2 = \underline{\hspace{2cm}}$$

$$\%Z_t^2 = \%R_t^2 + \%X^2 = \underline{\hspace{2cm}}$$

$$\%X = \sqrt{Z_t^2 - R_t^2} = \underline{\hspace{2cm}}$$

$$\left(\%R \text{ at } 75^\circ\text{C} \right)^2 = \left(\frac{\text{Total Cu. loss at } 75^\circ\text{C}}{\text{kVA} \times 10} \right)^2 = \underline{\hspace{2cm}}$$

$$\%Z = \sqrt{\%X^2 + \%R^2} = \underline{\hspace{2cm}}$$

$$\%G = \frac{x^2}{200} + R \text{ at } 75^\circ\text{C} = \underline{\hspace{2cm}}$$

$$\% \text{ Efficiency} = \frac{\dots \text{ kVA}}{\text{kVA} + \text{Total Losses}} \times 100 = \underline{\hspace{2cm}}$$

CONCLUSIONS



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CALCULATED FIGURES

GUARANTEED FIGURES

Power Factor _____

Power Factor _____

Load _____

Load _____

Efficiency _____

Efficiency _____

Regulation _____

Regulation _____

% Reactance _____

% Reactance _____

% Impedance _____

% Impedance _____

REMARKS

INSPECTOR : _____ DATE : _____

ENGINEER : _____ DATE : _____



Technical Specification
Specification No. TCPELE014TRANSFORMER

ANNEXURE 6

STATEMENT OF COMPLIANCE (TO BE COMPLETED BY TENDERER)

This tender complies with specification TCPELE014TRANSFORMER in all respects.

SIGNATURE : _____ DATE : _____

Transnet Group Capital

TECHNICAL SPECIFICATION:



Specification No. TPD: 001-EL&P SPEC

**SPECIFICATION FOR ELECTRICAL INSTALLATIONS TO
BUILDINGS OTHER THAN DWELLINGS HOUSES**



Technical Specification
Specification No. TPD: 001-EL&P SPEC

SPECIFICATION FOR ELECTRICAL INSTALLATIONS TO BUILDINGS OTHER THAN DWELLINGS HOUSES

REVISIONS		
REV	DATE	APPROVED
0	September 2022	
0	November 2025	

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1.0 SCOPE

- 1.1 This specification covers the requirements with respect to the electrical installation, including the supply of all material and labour necessary to complete the EL&P installation for buildings.
- 1.2 This specification also applies to electrical alterations and additions carried out to existing installations.

2.0 REFERENCES

- 2.1 The following publications (latest edition) are referred to herein:

CODES OF PRACTICE

SANS 10313		Code of Practice for Protection of Buildings against Lightning.
SABS 086	-	Installation and Maintenance of Electrical Equipment used in Explosive Atmospheres.
SABS 0108	-	The Classification of Hazardous Locations and the Selection of Electrical Apparatus for use in such Locations.
SABS 0114	-	Artificial Lighting
SANS 10142-1	-	Code of Practice for the Wiring of Premises
SABS 0199	-	Bulkhead Lighting Fittings (surface mounted).

SPECIFICATIONS

SABS 152	-	Low Voltage Air Break Switches, Connectors, Switch Disconnecters, Fuse Combination Units.
SABS 156	-	Moulded Case Circuit Breakers.
SABS 160	-	Electric Air Heaters.
SABS 162	-	Screwed Metal Conduit and Fittings for Electrical Wiring.
SABS 163	-	Wall and Appliance Switches.
SABS 164	-	Two Pole and Earthing Pin Plugs and Switch Socket Outlets
SABS 165	-	Lampholders
SABS 172	-	Cartridge Type Fuse Links
SABS 181	-	Thermostats for Electric Storage Heaters
SABS 314	-	Flameproof Enclosures for Electrical Apparatus
SABS 743	-	Low Voltage Isolating Transformers
SABS 767	-	Core Balance Earth Leakage Protection Units.
SABS 763	-	Hot Dip Zinc (galvanised) Coatings
SABS 784	-	Metal Enclosed Busbar Trunking Systems
SABS 890	-	Ballasts for Fluorescent Lamps
SABS 908	-	Meter Cabinets
SABS 950	-	Non-metallic Conduit and Fittings.
SABS 1012	-	Electric Light Dimmers
SABS 1041	-	Tubular Fluorescent Lamps
SABS 1065	-	Screwed Metal Conduit
SABS 1085	-	Wall Outlet Boxes.

SABS 1092	-	Contactors
SABS 1119	-	Interior Luminaires for Fluorescent Lamps.
SABS 1180	-	Electrical Distribution Boards.
SABS 1197	-	Metallic Wireways for installation in floors
SABS 1247	-	Coatings Applied by the Power-coating Process
SABS 1278	-	Interior Luminaires for Discharge Sodium Lamps
SABS 1279	-	Floodlight Luminaires
SABS CKS 50199	-	Bulkhead Luminaires (surface mounted)
SABS IEC 439	-	Low Voltage Switchgear
SABS IEC 309	-	Plugs, Socket Outlets and Couplers for Industrial Purposes
SABS IEC 742	-	Isolating Transformers and Safety Isolating Transformers

3.0 SERVICE CONDITIONS

3.1 The cable shall be designed and rated for continuous operation under the following conditions :-

3.1.1 Ambient/Environment Conditions :

- 3.1.1.1 Altitude : Sea level.
- 3.1.1.2 Ambient temperature : -5° C to +45° C (daily average +35° C).
- 3.1.1.3 Relative humidity : As high as 96%
- 3.1.1.4 Lightning conditions : Severe, with a maximum lightning ground flash density 11 flashes per km² per annum.
- 3.1.1.5 Exposure conditions : Salt laden, industrial atmosphere as well as hazardous gases and dust atmosphere.
- 3.1.1.6 Electrolytic corrosion conditions prevail in all the areas owing to the proximity of direct current traction system and cathodic protection schemes.

4.0 ELECTRICAL INSTALLATION

- 4.1 The contractor shall carry out the installation in accordance with SANS 10142-1: Code of Practice for the Wiring of Premises and the requirements of this specification.
- 4.2 Where the local supply authority requirements differ from those specified herein Transnet Projects Electrical Engineer shall be approached for a decision.
- 4.3 All equipment and material shall comply with the relevant National or International standard specification. Where equipment does not comply it shall be submitted with the Transnet Projects Electrical Engineer for approval.

- 4.4 The system of supply will be three phase, 4 wire or single phase 2 wire 50 Hz. alternating current with earthed neutral at a nominal voltage of 400/230 volts. The voltage may vary within the range of $\pm 5\%$ of the nominal voltage.
- 4.5 Wiring
- 4.5.1 All wiring shall be carried out in cable trunking and/or conduit. Only the loop in system of wiring shall be accepted.
- 4.5.2 Joints in wiring, nor the cutting away of strands to facilitate connections shall be permitted.
- 4.5.3 Single core cable smaller than 1,5 mm shall not be used. PVC cables shall not be connected directly to the lampholders for incandescent lamps. Conductors shall terminate in an approved connector in the conduit box directly behind the luminaire, and connection to the lampholder made by means of adequately rated silicone heat resistant wire.
- 4.5.4 Colour identification of conductors shall be used.
- 4.5.5 Flameproof equipment shall comply with SABS 314 or BS 229 for installation in hazardous areas, as defined in SABS 0108.
- 4.5.6 Equipment in hazardous areas shall be installed in accordance with SABS Code of Practice 086.
- 4.6 The provision and installation of the supply cable to the building, the termination and the connection thereof to the distribution board main incoming isolating shall be the responsibility of the Contractor, as directed by the Engineer.
- 4.7 The Contractor shall be responsible for the provision and connection of power supplies to electric urns, stoves, geysers, frytops, fans etc. provided by others; unless otherwise stated in the Schedule of Requirements.
- 6.7.1 The Contractor shall provide power supplies to air-conditioning equipment. The connection to air-conditioning equipment will be undertaken by others.
- 4.8 Cables shall be adequately supported to prevent strain on the terminals.
- 4.9 Drilling or welding of steelwork for the mounting of electrical equipment will not be permitted unless approved by Transnet's Civil Engineer on site. Equipment shall be fixed to the steelwork by means of approved, purpose made clamp/brackets.
- 4.10 Lightning protection shall be in accordance with the requirements of the local supply authority and SANS 10313 : Code of Practice for Protection of Buildings against Lightning.
- 5.0 DISTRIBUTION BOARDS**

- 5.1 Architrave type for flush mounting, and surface type for mounting on indoor walls shall comply with SABS 1180 Parts 1 and 2 respectively.
- 5.1.1 These distribution boards shall be supplied with a cover plate or open window door and be suitably painted and finished to harmonise with wall finish.
- 5.1.2 All switches and associated equipment shall be fully enclosed within the distribution board with only the operating handles protruding through the cover plate or door.
- 5.2 Cubicle type shall comply with IEC publication 439.
- 5.3 Distribution boards for outdoor use shall be weatherproof and corrosion resistant.
- 5.4 A substantial earthing terminal shall be firmly attached to the steel work of the distribution board and connected to the earthing bar.
- 5.5 Entries suitable for all incoming and outgoing cables shall be provided. Glands for bottom entry cables shall not be less than 600mm above floor level.
- 5.6 Space for mounting of 20% additional control units shall be allowed on all distribution boards. In addition, 20% spare conduits (20mm diameter) shall be provided between flush distribution boards and the ceiling/roof space in pitched roof buildings (minimum 2 conduits).
- 5.7 All circuits shall be clearly labelled. Labels shall be of the fabricated type and permanently secured. Embossed tape is not acceptable.
- 5.8 When called for labelling of moulded case circuit breakers shall be labelled by means of numerals. A legend inserted behind a clear plastic window on the inside of the door shall be provided to detail the various circuits.
- 6.0 ISOLATING SWITCHES**
- 6.1 Isolating switches for machines shall be lockable in the open position.
- 6.2 Isolating switches shall comply with SABS 152.
- 7.0 MOULDED CASE CIRCUIT BREAKERS**
- 7.1 Moulded case circuit breakers shall: -
- 7.1.1 comply with SABS 156.
- 7.1.2 have a breaking capacity as specified.
- 7.1.3 be of the fixed pattern, non-adjustable type.
- 7.1.4 be suitable for clip-on tray mounting.

8.0 EARTH LEAKAGE PROTECTION UNITS

8.1 Earth leakage protection units shall: -

8.1.1 be the integral moulded case type and comply with SABS 767.

8.1.2 have a sensitivity of 30 mA.

8.1.3 be similar in design to moulded case circuit breakers and suitable for clip-on tray mounting.

8.1.4 have a breaking capacity and current rating as specified.

9.0 FUSE SWITCHES

9.1 Fuse switches shall :

9.1.1 comply with SABS 152

9.1.2 be of the double break, horizontal drawout, air insulated type, suitable for flush mounting.

9.1.3 be of the quick break, dustproof type.

12.0 HIGH RUPTURING CAPACITY FUSE LINKS

12.1 High rupturing capacity fuse links shall :

12.1.1 comply with SABS 172

12.1.2 be of the cartridge type with a breaking capacity not less than that shown in the Category of Duty AC 50 table 2 of SABS 172.

12.1.3 have a class Q1 fusing factor

12.1.4 A spare set of fuse links for each of the different ratings shall be provided and accommodated in the distribution board.

13.0 CONTACTORS

13.1 Contactors shall comply with SABS 1992.

14.0 LUMINAIRES FOR INCANDESCENT LAMPS

14.1 Luminaires shall be suitable for accommodating 100 watt B.C. lamps.

14.2 The insulation of internal wiring shall be heat resistant.

14.3 Bulkhead luminaires shall comply with CKS 199.

14.4 Bowl type luminaires shall have porcelain or acrylic galleries with white opal, high impact acrylic screw-in type bowls.

14.5 Well glass luminaires shall consist of a body of non-corrosive material with a top entry for a 20mm conduit, have a clear glass cover and be completely weatherproof.

15.0 LUMINAIRES FOR FLUORESCENT LAMPS

15.1 Luminaires for fluorescent lamps shall comply with SABS 1119.

15.2 Lampholders shall be of the telescopic type.

15.3 The luminaires shall be suitable for 1,2m or 1,5m "rapid start" lamps to SABS 1041, class B, group 2, with rated colour 3. (warm white).

15.4 Anti-corrosive luminaires shall have a body channel constructed of fibre-glass or non-corrosive material with a moulded acrylic enclosing diffuser.

15.5 A gasket shall be provided between the body channel and the diffuser to ensure a reliable seal.

15.6 The enclosing diffuser shall latch to the body channel with captive-type non-corrosive latches.

15.7 It is essential that full descriptions and photometric data of the luminaires and lamps offered, accompany tenders. This information shall include description and drawings of the various items of equipment as well as full photometric data issued by the South African Bureau of Standards.

16.0 INTERIOR LUMINAIRES FOR HIGH INTENSITY DISCHARGE LAMPS

16.1 Interior luminaires for high intensity discharge lamps shall comply with SABS 1278 and be suitable for use in an ambient temperature of 40°C.

16.2 Suitable provision shall be made on the ballast housing for eyes or lugs, for the attachment of safety chains.

16.3 The electronic ignition device for high pressure of sodium and metal halide lamps shall be of the three wire type operating on the superposed pulse principle. The circuitry shall be such that at starting, or on failure of a lamp, high voltage pulses will be confined to the high voltage lead between the igniter and centre contact of the lampholder. Igniters incorporating a switching element are not acceptable.

16.4 A fully electronic ignition circuit shall be utilized to trigger the pulse transformer.

16.5 The natural frequency of the electronic ignition circuit shall be in the order of 100kHz.

16.6 The lamp ignition voltage shall remain constant within a mains voltage variation of between 200 and 250 volts.

16.7 Tenderers shall guarantee that pulsing of the igniter on a failed lamp will not have a detrimental effect on the life and efficient operation of the control gear, igniter, lampholders and circuit wiring.

16.8 It is essential that full descriptions and photometric data of the luminaires and lamps offered, accompany tenders. This information shall include description and drawings of the various items of equipment, as well as full photometric data issued by the South African Bureau of Standards.

17.0 ELECTRIC AIR HEATERS

17.1 Electric air heaters shall comply with SABS 160.

17.2 Tubular heaters shall be rated at 260 watt per metre length of tube and have an enclosed entry box containing terminals for incoming line, neutral and earth connections with a suitable entry for a flexible conduit connector.

17.2.1 Tubular heaters shall be mounted with the bottom 200mm above floor level

17.3 Convector Heaters shall:

17.3.1 be of the natural convection type, of good appearance and suitable for flush or surface mounting.

17.3.2 have incorporated a manually adjustable control switch, automatic controlling thermostat and indicating neon pilot lighting showing when the heater is on.

17.3.3 have a mounting box or housing suitable for a 20mm electrical conduit entry.

17.3.4 be installed with the bottom of the mounting box/housing 200mm above floor level.

17.4 Fan Heaters shall :

17.4.1 be of the wall mounted type with air flow directional adjustment and locking facilities.

17.4.2 have a totally enclosed type fan motor fully protected from damp and dust and fitted with self aligning noiseless bearings.

17.4.3 have a separate manually adjustable control unit incorporating an automatic controlling thermostat. The control unit shall be housed in a adequately ventilated sheet steelcase. Means of protecting and isolating the heater, shall be provided. The control unit circuit shall be arranged such that during summer months the heater can be switched off and the fan used alone for ventilation.

18.0 ROOM THERMOSTATS

18.1 Room thermostats shall comply with BS 3955 Part 2, section 2F, and be to category A.

18.2 An over-riding switch shall be mounted adjacent to the thermostat for manual control.



19.0 LIGHT SWITCHES

- 19.1 Light switches shall comply with SABS 163 and be of the rocker type.
- 19.2 They shall be mounted 1 500 mm above floor level and where possible 200 mm from door frames.

20.0 LIGHT SENSITIVE CONTROL UNITS

- 20.1 The complete unit shall be of the solid state type and housed in a sealed weatherproof enclosure suitable for mounting in any position.
- 20.2 The light sensitive cell shall operate in a manner to give an area of detection not less than a hemisphere.
- 20.3 The unit shall not operate due to light fluctuations of duration less than 5 minutes. They shall incorporate main contacts rated at least to 10 amps and be mounted at a height of not less than 2 400 mm.
- 20.4 An over-riding switch shall be provided.

21.0 SOCKET OUTLETS

- 21.1 All 220 volt, 16 amp socket outlets shall comply with SABS 164 and be of the 3 round pin shuttered type.
- 21.2 All 32V, 5A socket outlets for lead lights shall be of the industrial two pin, weatherproof type with a screw cover attached to the socket outlet by a short length of chain.
 - 21.2.1 They shall be mounted on columns/walls 1 500mm above floor level or in recesses provided in inspection pits.
- 21.3 Welding socket outlets shall be in accordance with IEC publication 309 and be rated for 63A (unless other rating is indicated on the drawing) and be of the 5 pin, 6 h configuration type.
 - 21.3.1 Welding plugs shall be supplied complete with matching male plugs and be mounted 1 500mm above floor level.

22.0 TRANSFORMERS 220V/32V

- 22.1 The transformers for 32V socket outlets shall be in accordance with SABS SV 118 and be designed for 220V to 250V primary power supply and have an output voltage of 32V.

23.0 ISOLATING AND SAFETY ISOLATING TRANSFORMERS

- 23.1 Isolating and safety isolating transformers shall comply with SABS IEC 742 and SABS 743.

24.0 POWER POINTS

- 24.1 Power points for hot water cylinders shall be equipped with a 2 or 3 pole isolating switch adjacent to the cylinder except for hot water cylinders mounted below sinks.
- 24.2 Where contactors are necessary for the operation of hot water cylinders these shall be installed adjacent to the appliance where practicable and in a suitable enclosure.
- 24.3 Power points for tubular heaters shall be equipped with a flush mounted 100mm x 100mm conduit box, blanked off with a cover plate accommodating a 15A flush mounted switch. Connection to the heater shall be by means of a PVC covered flexible conduit. The flexible conduit shall have sufficient slack to avoid strain but shall not touch the floor.
- 24.4 Power points for fan heaters shall be equipped with two recessed interconnected conduit boxes, one for connection to the heater and the other for connection to the control unit 1 500mm above floor level.
- 24.5 Power points for stoves, fry tops and boiling tables shall be equipped with a 2 or 3 pole isolating switch for the appliance shall be 1 500mm above floor level. The outlet for connection to the appliance shall be 500mm above floor level.
- 24.6 Power points for air-conditioning units shall terminate in a 100mm x 100mm conduit box mounted adjacent to the unit and equipped with a 2 pole isolating switch.
- 24.7 Power points for extractor fan units shall terminate in a 100mm x 100mm conduit box mounted adjacent to the unit.
- 24.8 Where a common thermostat is specified for controlling a number of fans, power points shall be so arranged to allow for circuit wiring between the fans and thermostat.
- 24.9 Power points for smoke detection and CO₂ equipment shall terminate in a 100mm x 100mm conduit box equipped with a 30A, 2 pole isolating switch, lockable in the "on" position, mounted 1500mm above floor level, with connecting facilities to the equipment.
- 24.10 Power points for air conditioning units shall terminate in a 100mm x 100mm conduit box mounted adjacent to the unit and equipped with a 2 pole isolating switch, with connecting facilities for the unit.
- 24.11 Power points for machinery shall terminate in a connection box suitable for mounting a 2 or 3 pole isolating switch, with connecting facilities to the machine.
- 24.12 Power points for lighting shall terminate in a circular conduit box fitted with an unswitched 5 A 3 pin socket outlet.

25.0 CONDUIT AND ASSOCIATED FITTINGS

- 25.1 Screwed metal conduit shall comply with SABS 162.

- 25.2 Non-metallic conduit and fittings shall comply with SABS 950. Non-metallic conduit shall not be cast into concrete.
- 25.3 Wall outlet boxes shall comply with SABS 1085.
- 25.4 In areas within 50 km of the coast only galvanised or non-metallic conduit shall be used. Where conduit is exposed to the weather elements only galvanised conduit shall be used or UV T. Routed P.V.C. pipe.
- 25.5 Threads of metallic conduit and associated fittings shall be effectively protected against rust by non-corrosive paint where they are exposed to moisture or weather elements.
- 25.6 Wall outlet boxes shall be positioned with the major dimension vertical and not more than 15 mm below the finished wall surface. Cover plates shall fit plumb and flush with wall surfaces.
- 25.7 Conduits are to be concealed and chased into plastered brick walls or cast into concrete work as building work proceeds. Where conduit cannot be concealed these shall be installed neatly on the surface as approved by the Engineer.
- 25.8 Conduits are to be concealed and chased into plastered brickwalls or cast into concrete work as the building work proceeds.
- 25.9 Chasing of finished walls or concrete work will not be allowed. Under no circumstances will chases be permitted through structural members of the building.
- 25.10 Chasing of face brick walls will not be permitted. Conduits and outlet boxes shall be built into walls.

26.0 CABLES AND GLANDS

- 26.1 Polyvinyl-chloride cables shall comply with SABS 150. Armoured cables shall be of the earth continuity conductor type.
- 26.2 Cable glands shall be of the compression type, (brass or bronze) and be suitable for termination of earth continuity conductor type cables. Glands shall be supplied with neoprene shroud.

27.0 BUSBAR TRUNKING

- 27.1 Busbar trunking shall comply with SABS 784.

28.0 CABLE TRAYS

- 28.1 Cable trays shall be protected against corrosion and be adequately supported so that when fully loaded the deflection does not exceed 10mm. They shall be wide enough to accommodate the power cables in a single layer.

29.0 EARTHING AND BONDING

- 29.1 The complete electrical installation shall be earthed in accordance with SABS 10142-1: Code of Practice for the Wiring of Premises.
- 29.2 Earth electrodes shall consist of an exterior copper layer molecularly bonded to a high strength steel core. The copper shall have a minimum thickness of 0.25mm.
- 29.3 Only approved non-corrosive substances may be used to reduce earth resistivity. The earth resistance as measured with a earth resistance tester shall not exceed 5 ohm.
- 29.4 Copper tape used for bonding and earthing of waste pipes shall have a minimum cross sectional area of 12mm², and when run along walls shall be fixed by means of non-ferrous screws in plastic plugs at intervals of 300 maximum.

30.0 PAINTING

- 30.1 All surfaces of distribution boards shall be light orange to SABS 1091 colour No. B26 unless otherwise stated in the Schedule of Requirements attached to this specification.
- 30.2 All surfaces shall be cleaned according to the appropriate method described in SABS 064 for the particular surface to be cleaned, the contamination to be removed and the primer to be applied.
- 30.3 Components that will be powder coated shall be cleaned and prepared in accordance with the requirements of SABS 064. Powder coating shall comply with the requirements of SABS 1274 - 1979 Type 4; Corrosion resistant coatings for interior use and using thermosetting high gloss coating.
- 30.4 All specified coatings shall be applied according to the relevant specification and the manufacturers instructions shall be followed. Coatings shall not be applied in conditions which may be detrimental to the effectiveness of the coating, or the appearance of the painted surface.
- 30.5 When examined visually the finished product shall have a uniform appearance as far as gloss is concerned and shall show no sign of damage. Damaged areas shall be repaired coat for coat to obtain the desired finish.

31.0 TESTS

- 31.1 Insulation, continuity and earthing tests in accordance with SANS 10142-1 shall be carried out to the satisfaction and in the presence of the Engineer or authorised deputy on completion of the work.
- 31.2 An installation Certificate of Compliance for the electrical installation issued by an accredited person as required by the Occupational Health and Safety Act, 1993 (Act 85 of 1993) shall be provided.
- 31.3 The Contractor shall provide the necessary approved instruments.



31.4 Transnet Projects reserves the right to use its own instruments should it be considered necessary.

WITNESSES

1.

.....
TENDERER

2.

.....
DATE

**Transnet Projects
Design Services**

TECHNICAL SPECIFICATION:



Specification No. TPD: 002-DBSPEC

**SPECIFICATION FOR LOW VOLTAGE DISTRIBUTION
BOARDS**



SPECIFICATION FOR LOW VOLTAGE DISTRIBUTION BOARDS

This specification covers Transnet's requirements for low voltage distribution boards

REVISIONS		
REV	DATE	APPROVED
0	September 2022	
0	November 2025	

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1. SCOPE

1.1. This specification covers Transnet's requirements regarding the design, supply, manufacture, population, works testing, delivery to site, site erection, site testing and commissioning of low voltage Distribution Switchboards consisting of fuse switches incorporating high rupturing capacity cartridge fuse links, air circuit breakers, moulded case circuit breakers and auxiliary equipment. The tenderer is required to familiarise themselves with all applicable Standards and Codes of Practice listed herein, and to ensure compliance in the execution of any work in terms of this document.

2. REFERENCES

2.1. The following publications (latest edition) are referred to herein:-

2.1.1. SOUTH AFRICAN BUREAU OF STANDARDS

Codes of Practice

SANS064	The preparation of steel surfaces for coating
SANS10111	Engineering Drawings.
SANS10142	Wiring of premises Part 1: Low voltage installations
SANS10313	Protection against lightning - Physical damage to structures and life hazard

Specifications

SANS60947	Low-voltage switchgear and control gear
SANS156	Moulded-case circuit breakers
SANS60269	Low-voltage fuses
SANS1091	National colour standards for paint
SANS1195	Busbars
SANS1274	Coating applied by the powder coating process
SANS1973-1	Low-voltage switchgear and control gear assemblies Part 1: Type-tested assemblies with stated deviations and a rated short-circuit withstand strength above 10 kA
SANS1973-3	Low-voltage switchgear and control gear assemblies Part 3: Safety of assemblies with a rated prospective short-circuit current of up to and including 10 kA
SANS60529	Degrees of protection provided by enclosures (IP Code)
SANS1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SABS ISO 9000	Quality management systems -- Fundamentals and vocabulary
SANS1019	Standard voltages, currents and insulation levels for electricity supply
SANS170	Fasteners

International Electrotechnical Commission

BS 3938	Current Transformers
IEC 61508	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems.
IEC 60051	Direct acting indicating analogue electrical measuring instruments and their accessories

3. SERVICE CONDITIONS

3.1 The equipment shall be designed and rated for continuous operation under the following conditions:-

3.1.1 Ambient/Environment Conditions:

- 3.1.1.1 Ambient temperature- 5°C to +40°C (daily average +35 °C).
- 3.1.1.2 Relative humidity- As high as 95%
- 3.1.1.3 Lightning conditions- Severe, with a maximum lightning ground flash density of eleven (11) flashes per km² per annum.
- 3.1.1.4 Atmosphere- Salt laden and corrosive industrial atmosphere

3.1.2 Electrical Conditions:

- 3.1.2.1 The system of supply shall be three phase, 4 wire, 50 Hz alternating current with solidly earthed neutral at a nominal voltage of 400 / 231 Volts.
- 3.1.2.2 The voltage may vary within the range of 95% to 105% of the nominal and all equipment installed shall be suitably rated.
- 3.1.2.3 All equipment shall be adequately rated for prospective fault level ratings.

4 DRAWINGS AND INSTRUCTION MANUALS

- 4.1 All drawings shall be in accordance with SANS 10111 – Engineering Drawings.
- 4.2 The successful tenderer shall supply the following instruction manuals, all of which shall be included in the tender price and be to the satisfaction of Transnet.
 - 4.2.1 THREE (3) sets of detailed drawings and instruction manuals, with illustrations where necessary and 2 sets of prints of the "As Built" General Arrangement drawings and the schematic and wiring diagrams to facilitate erection and adjustment of the switchgear.
 - 4.2.2 A full set of electronic media including all information requested above.
 - 4.2.3 These instruction manuals and drawings shall be supplied as soon as possible after placing of the order, but before delivery of the equipment.

5. STANDARD OF WORK, EQUIPMENT & MATERIALS

- 5.1. The distribution board shall conform to the requirements of the latest edition and amendments of SANS 10142-1 Code of Practice for the Wiring of Premises Part 1: Low voltage installations and any additional requirements thereto, described in this specification.
- 5.2. All equipment and material used shall be of high quality and the work shall be of a high standard of workmanship carried out by qualified staff under proper supervision by experienced and competent officers.
- 5.3. If any special tools are required for the maintenance of the switchboard, the tenderer shall supply three (3) sets at delivery of the switchboard to site.

6. DISTRIBUTION BOARDS

6.1. The distribution board shall comply with SANS 60439-1

6.1.1. The form of separation will be specified in the project specific documentation.

6.2. The degree of protection shall be to IEC Publication 144/EN60529 and shall conform to the following:

- Inside Substations and MCC Rooms: IP42
- Other Locations: IP65

6.3. The distribution board shall consist of either a framework of substantial steel sections covered with heavy gauge steel plates or of folded sheet steel sections, forming a robust construction.

6.4. Particular attention shall be given to the ventilation of panels, to eliminate build-up of excessive heat caused by the sun or internal heat generation. All necessary precautions shall be taken to ensure that the temperature of the air in any portion of the assembly does not rise more than 15°C above ambient air temperature

6.5. Every board shall be fitted with a suitable gasket incorporated into the frame to ensure that the arrangement is in accordance with the required degree of protection. Sealing strips and gaskets shall be made of durable, non-hardening rubber, neoprene or other synthetic material, suitably fixed to the door or frame to ensure that the seal does not become dislodged during normal operation.

6.6. Where possible the lock and door catch shall comprise of a combination unit. Door latching and delatching operations shall be smooth and quick, whilst ensuring proper compression of the sealing gaskets. Repeated opening and closing of the hinged doors and operations of the door locks and catches shall not cause chipping or scratching of the painted surfaces or any other blemishes to the finished boards

6.7. Lifting lugs shall be provided for floor standing enclosures and as needed for wall mounted enclosures.

6.8. The board shall have a separate latches hinged or removable front cover secured to the board by means of suitable captive type screws or bolts. When the cover is removed/ opened, easy access to that compartments components and wiring shall be possible.

6.8.1. The control units shall be mounted flush with the front cover so that only the operating handles protrude.

6.8.2. Large removable panels shall be supplied with handles for easy handling.

6.8.3. No possibility should exist for panels to come into contact with live parts.

6.9. Due care shall be taken to ensure that the live side of the MAIN SWITCH is suitably protected so that no live conductors are exposed when the panel door is opened or the panel cover is removed.

6.10. The board shall be equipped with a set of 3 phase and neutral copper busbars. The 3 phase busbars shall be continuously rated for the full load of the incoming supply switch. The neutral shall be 100% of the phase busbars. Earth bar shall be rated to fault current and touch voltage.



- 6.11. All busbars shall be designed, manufactured, marked and tested in accordance with SANS1195.
- 6.12. Busbar rating shall be $2A/mm^2$ up to 630A and $1.6A/mm^2$ thereafter.
- 6.13. Busbar temperature shall not exceed a $40^{\circ}C$ temperature rise.
- 6.14. The busbars shall be adequately braced and supported. The busbars shall be covered with a sufficient number of layers of high quality insulating tape or heat shrinkable sleeving and finished in standard colours.
- 6.15. Where busbar joints and terminations have not been covered, a kit shall be provided for covering during installation.
- 6.16. Alternatively, busbars shall be suitable enclosed in a busbar chamber or behind a protective barrier for protection against inadvertent contact with "live" busbars with access panels removed.
- 6.17. Inter-connectors between the busbars and control units shall be by means of fully insulated, adequately rated conductors firmly bolted to the busbar and secured to the appropriate terminals of the control units using crimped-on terminal lugs. Solid flat conductors shall be used if the rating exceeds 400 A or if the fault current exceeds 25kA rating. No conductor of less than $16mm^2$ shall be used between busbars and control units. All conductors shall be suitably rated for the fault level.
- 6.18. The other terminals of the incoming and outgoing panel units shall be connected by means of conductors conforming to clause 6.17, i.e. they shall be robust, insulated, easily accessible terminals, of adequate size, conveniently located in the distribution board near the incoming and outgoing cable entries but with sufficient clearance and space to enable the incoming and outgoing cables to be connected to their corresponding terminals without difficulty or strain.
- 6.19. All the outgoing connections of MCCB'S greater than 400A 3 phase shall be done by means of copper bus bars, securely clamped using approved busbar clamping insulators, fixed to a robust metal section of adequate size, conveniently located in the rear of the distribution board to enable the incoming cables to be terminated in the back of the distribution board cubical behind each respective MCCB. This is to allow for the easy termination of the larger incoming cables, with sufficient clearance and space to enable the outgoing cables to be connected to their corresponding busbar terminals without difficulty or strain to the MCCB's. Each MCCB up to 250A shall be fitted with extended terminal complete with phase barriers as supplied by circuit breaker supplier.
- 6.20. Outgoing cable tails that connect to the busbars in clause 6.19 shall have securing places to enable the cable to be secured with nylon type cable fasteners in an approved manner.
- 6.21. The busbars that protrude into the back compartment of the distribution board shall be covered with a perspex type barrier and shall have danger signs on each section.
- 6.22. Removable gland plates shall be provided. These gland plates shall be of adequate thickness or construction for the cables to be terminated without distortion of the gland plate, and shall not be less than 2mm mild steel (zinc passivated). Gland Plates shall not be mounted less than 300mm above ground floor level, alternatively a base frame of suitable depth may be provided.
- 6.23. Distribution board cases shall be of such dimensions that adequate space is available for manoeuvring and connecting the incoming and outgoing cables.



- 6.24. All cable entries shall be from the bottom of the distribution board unless stated otherwise.
- 6.25. Glands shall not be less than 300mm above floor level. Unless otherwise stated.
- 6.26. The terminals of all incoming and outgoing cables shall be firmly connected to the terminals on the lugs or ferrules, unless they are of a type that will grip the cable without splaying the strands of the conductor.
- 6.27. A substantial earthing terminal shall be firmly attached to the metal work of the distribution board and connected to an earth bar of cross sectional area not less than 50% of the phase bars, running the full length of the distribution board to which all earthing conductors of the incoming and outgoing circuits shall be firmly connected.
- 6.28. A removable link shall be provided in the Neutral busbar to ensure that the neutral busbar can be split in two sections for testing purposes. The link shall be secured in position with a bolt and nut arrangement.
- 6.29. The distribution board manufacturer shall allow for at least 30% capacity for the installation of additional switchgear in the distribution boards.
- 6.30. Each distribution board shall be fitted with the following labels as needed in suitable positions:
- Live busbars
 - Flash signs
 - Main label (always required)
 - Voltage rating
 - Current rating
 - Fault level and time
 - IP rating
 - Job number
 - Reference number
 - Date of manufacture
 - Form of separation
 - Fed from
 - Each feeder/starter to be labelled
- 6.31. Each distribution board shall be supplied with a test certificate. This certificate shall include all items as indicated in annexure 1 of SANS 1973-1 and annexure E of SANS 1973-3.

7. ARC DETECTION SYSTEM

7.1. All switchgears shall be equipped with an efficient and reliable arc detection system designed according to IEC 61508 with a safety level meeting at least SIL 2.

7.2. The system shall consist of one or more arc monitoring units and light detectors.

7.2.1. Arc detection system:

Arc detection system shall not be activated by interfering influences such as portable lamps, electro-magnetic fields, vibration or touching. In case of an arc occurring in the switchgear it shall be possible to identify where and when the arc has occurred. This information should be accessible without opening the switchgear door and stored even if power is lost to the system. The HMI shall not affect the IP degree of the cabinet.



7.2.2. Arc monitoring unit and light detector:

The arc detection system shall use light as the main condition for tripping. Detectors shall cover each bus-bar section, respective circuit breaker and in any other areas where the designer of the switch gear considers or finds it as a potential risk for an arc. The detectors shall be made of optical fibre in order to avoid EMC disturbances. Without any extra calibration from the user the system shall not react for a light intensity lower than 3000 lux in order to avoid nuisance tripping. The light intensity shall also be constant regardless the length of the detector.

7.3. The trip signal shall be sent within less than 2 ms to the circuit breaker in an event of an arc

7.4. The arc monitoring unit shall provide at least three high speed solid state tripping outputs to the circuit breaker.

7.5. It shall be possible to configure the detectors to trip different breakers depending on which detector detects the arc.

7.6. The system shall have the possibility to mount up to 30 detectors in the space of the main unit in order to avoid space issues if the system would be extended.

8. FUSE SWITCHES

8.1. Fuse switches shall comply with SANS 152 and SANS 60947 – 3.

8.2. Fuse switches shall be enclosed, triple pole, quick break and dustproof.

8.3. Fuse switch handle shall have an IP rating of IP65 and the handle shall be defeatable to override the door interlock.

8.4. Fuse switches shall be of the double break type and the fuses shall be completely isolated when the switches are in the "OFF" position.

8.5. Fuse switch and handle shall have a test position. It will be possible to have an auxiliary for only indication test position.

8.6. The switches shall be interlocked to prevent the opening of the front covers unless the switches are in the "OFF" position and the closing of the switches with the covers open. The switches shall be lockable in the "OFF" position.

8.7. Fuse Switches shall have a lever or rotary action with a positive spring controlled opening and closing action for making or breaking the circuit under load conditions. Fuse carrier and base contacts shall be designed to give permanent high contact pressure and shall be designed to facilitate location of blown fuses without removal of the carrier. Fuse carriers and bases shall be of the highest grade phenolic mouldings to BS 771 and shall be non-flammable and nonhygroscopic, with a hard gloss black finish.

8.8. It shall be possible to install the fuse switch in any position without derating.

9. FUSE LINKS

9.1. HRC Fuse Links shall be of the high rupturing capacity type, compliant with SANS IEC 60269 –

1:2006. Fuse links shall incorporate a visual indication device to facilitate location of blown fuses and shall be designed to clip into the fuse carrier contacts without the use of fixing screws.

9.2. Breaking capacity of all fuse links shall be not less than Category of duty AC.50 at 415 Volts (SANS IEC 60269 - 1:2006). The Fusing factor of the fuses shall not exceed 1.5 (SANS IEC 60269 Class Q1).

9.3. Fuse current ratings shall be indicated on engraved 20 x 12mm white-black-white trifoliate labels in 4mm letters. The labels are to be fitted at the fuse bases and shall not be obscured by wiring.

9.4. Fifty- percent spare fuses of each size shall be provided in suitable cubicle on the switchboard. The door of this cubicle shall be suitably identified.

10. AIR CIRCUIT BREAKERS (ACB) SHALL CONFORM TO THE FOLLOWING CHARACTERISTICS.

10.1. Functional characteristics:

10.1.1. Air circuit breakers for use on the incoming supply side of the distribution board shall comply with SANS 60947.

10.1.2. The circuit breakers shall have a continuous enclosed current rating as indicated on the relevant drawings with a minimum Icu (ultimate breaking capacity) of 42kA at 415 volts. The circuit breakers shall be tested for category P.2, unless specified otherwise.

10.1.3. The circuit breakers shall have an Ics (service capacity) rating equal to the Icu (ultimate breaking capacity) rating.

10.1.4. The circuit breakers shall have an Icw (withstand current) of 1 sec and 3 sec. The 1 sec Icw rating shall be equal to the Icu rating.

10.1.5. The air circuit breakers shall be of the enclosed, ventilated, independent manual spring, draw-out type with a rated service voltage of 690 volts and a rated insulation voltage of 1000 volts and be equipped for shunt tripping from a 115 V DC battery supply. The shunt tripping facility shall be wired so that the ACB shall trip when it's associated high voltage transformer circuit breaker trips.

10.1.6. The circuit-breakers shall have a rated impulse withstand voltage of 12 kV.

10.1.7. The rated uninterrupted current shall be between 100 and 6300 A with the possibility of set trip threshold of L protection from 40A.

10.1.8. Different versions of circuit-breakers shall be available, divided into their category of use: A (current-limiting) and B (selective).

10.1.9. Different versions shall be available with rated ultimate breaking capacity from 42 to 150 kA at 440 V AC and from 42 to 100 kA at 690 V AC for circuit-breakers in category B and with 130 kA at 415 V AC, 85 kA at 690 V AC for circuit-breakers in category A.

10.1.10. The mechanical life shall be at least 12000 operations with a frequency of 60 operations/hour without the need for maintenance of the contacts and arcing chambers

- 10.1.11. The electrical life at a voltage of 440 V AC shall be (with a frequency of at least 10 operations/hour and without the need for maintenance of the contacts and arcing chambers):
- at least 9000 operations up to 2000 A
 - at least 5000 operations up to 3200 A
- These values are intended to be valid only for category B circuit-breakers.

10.2. Environmental characteristics

- 10.2.1. Operating temperature: -25 °C...+70 °C (-13 °F...158 °F) and storage temperature: -40
- 10.2.2. Altitude: operation without derating shall be up to 2000 metres above sea level. (6600 ft), and with derating up to 5000 metres above sea level. (16500 ft).
- 10.2.3. Suitability for use in a hot-humid environment. With regard to this, the circuit-breakers shall undergo a tropicalisation process which makes them suitable for use in a hot-humid environment, as established by the prescriptions of the main shipping registers and in accordance with the international IEC 60068-2-30 Standards.

10.3. Construction characteristics

- 10.3.1. All the models shall be available in the 3 and 4 pole versions both in the fixed (with rear horizontal, rear vertical and front terminals) and withdrawable (with rear horizontal, rear vertical, front and fl at terminals) versions.
- 10.3.2. There shall be total segregation between power and front shield, using double insulation where suitable so as to guarantee maximum operator safety.
- 10.3.3. Total segregation between the phases shall be guaranteed for safety reasons without need of phase barriers up to 1000V.
- 10.3.4. It shall be possible to inspect easily the arcing chambers easily and to check main contact wear with the circuit-breaker racked-out, by removing the arcing chambers.
- 10.3.5. All the circuit-breakers in the range shall have the same height and depth with the aim of standardising the supporting structures of the switchgear and the switchgear itself as far as possible.
- 10.3.6. IP30 degree of protection shall be guaranteed on the front part and IP20 on the rest of the circuit-breaker (excluding the terminals), with the possibility of having IP54 degree of protection (NEMA 3/3s/13) on the front, using the transparent cover which completely protects the front, but still leaves the panel underneath and the protection unit fully visible with the relative indications.
- 10.3.7. The whole range of air circuit-breakers shall be fitted with electronic protection releases. It shall be allowed the inter-changeability of protection releases from skilled personnel.

10.4. Special points for withdrawable versions:

- 10.4.1. The circuit-breakers in the withdrawable version shall be fitted with anti-racking-in locks to prevent racking a moving part into a fixed part with a different rated current.
- 10.4.2. In the case of the withdrawable version, the presence of a device shall prevent racking-out and racking-in with the apparatus closed.





10.5. Accessories

The following accessories shall be common to the whole range standard:

10.5.1. Electrical accessories:

- 10.5.1.1. Shunt opening/closing release.
- 10.5.1.2. Control and monitoring Test Unit - allows continuity of the different versions of the shunt opening releases to be checked;
- 10.5.1.3. Undervoltage release;
- 10.5.1.4. Time delay device for undervoltage release - allows release trip delay with established and adjustable times;
- 10.5.1.5. Geared motor for the automatic charging of the closing springs;
- 10.5.1.6. Mechanical and electrical signalling of overcurrent release trip;
- 10.5.1.7. Trip reset release;
- 10.5.1.8. Auxiliary contacts which allow signalling of the circuit-breaker state;
- 10.5.1.9. Current transformer for the neutral conductor outside the circuit-breaker;
- 10.5.1.10. Homopolar toroid for the main power supply earth conductor (star centre of the transformer).

10.5.2. Mechanical accessories:

- 10.5.2.1. Interlocks between 2 circuit-breakers or among three circuit-breakers can be used horizontally, vertically or in "L" position using different types of flexible cables:
- 10.5.2.2. Standard version (with maximum distance between two circuit breakers: up to 1200 mm if horizontally interlocked while up to 750mm if vertically interlocked).
- 10.5.2.3. Extended version (with distance between two circuit breakers: from 1200mm up to 1600 mm if horizontally interlocked while from 750 up to 1000 if vertically interlocked).
- 10.5.2.4. Mechanical locks to control enabling racking-in/out operations available also with interlocks. IP54 transparent front protection (NEMA 3/3S/13).

10.6. Protection Release

10.6.1. Basic Protection Functions

- 10.6.1.1. The release shall not require auxiliary power supplies since the power is taken from the current transformers.
- 10.6.1.2. The signals supplied by the release shall not operate with power supply supplied by internal batteries.



- 10.6.1.3. The protection against overload (L) with characteristic $t=k/I^2$ shall always have setting ranges with timing adjustable up to 144s with $I=3I_n$.
- 10.6.1.4. The protection of neutral shall be set at 50%, 100%, 200% and OFF of the phase currents without changing any component.
- 10.6.1.5. All the protection functions except protection against overload shall be excludable.

10.6.2. Measurement Functions

- 10.6.2.1. The release shall always be able to provide measurement of the currents and voltages in the three phases, in the neutral and of earth fault (ammeter function), both in self-supply and with an auxiliary power supply. Measurement function shall be active, even without external supply, starting from 140 A of single-phase current, independently from the circuit-breaker size. Accuracy of the ammeter measurement chain (current sensor plus ammeter) shall equal or better than 1.5% in the 30% - 120% current interval of I_n .
- 10.6.2.2. The release shall not normally require auxiliary power supplies since the power is taken from the current transformers. For measurements and programming at very low currents, a power supply at 24 V DC shall be available. As alternative the release shall be able to receive power supply directly from busbars or terminals, up to line voltage equal to 690 V AC.
- 10.6.2.3. The release shall be able to acquire the waveforms of electrical values with a sampling frequency selectable from 600 to 4.800 Hz and sampling interval from 3 s to 27 s. Acquisition shall be frozen after a trip or a configurable event. Acquisition data shall be retrieved from an external device (personal computer or similar) for fault analysis purposes. The release shall show voltage measurements on display, with a precision equal or higher than 1%.
- 10.6.2.4. Measurement functions that shall be available:
 - Current measurements
 - Voltage measurements
 - Power measurements
 - Power factor measurements.
 - Measurements of frequency and peak factor
 - Energy measurements
 - Historical measurements
 - The last 10 trips information
 - Complete trip information on display without batteries
 - Data logger included as standard

10.7. Advanced Protections Functions

- 10.7.1. Thermal memory for functions L (overload protection) and S (short circuit protection).
- 10.7.2. Protection against over-temperature. It shall be possible to signal the presence of anomalous temperatures on the release by means of two LEDs (Warning and Alarm) and, if decided during the unit configuration phase, when the temperature is over 85 °C, to simultaneously control circuit-breaker opening.



- 10.7.3. Protection against missing and unbalanced phase (U) with characteristic $t=k$ shall be possible.
- 10.7.4. Load control protection (K).
- 10.7.5. Undervoltage protection (UV)
- 10.7.6. Overvoltage protection (OV)
- 10.7.7. Residual voltage protection (RV)
- 10.7.8. Underfrequency protection (UF)
- 10.7.9. Overfrequency protection (OF)
- 10.7.10. Protection against reversal of active power (RP)

10.8. User Interface and Signalling LEDs

- 10.8.1. An alarm shall indicate by means of LEDs located on the release the disconnection of opening solenoid and current transformers. A trip shall also occur, after a short time delay, when the disconnection is detected.
- 10.8.2. The release shall allow parameterisation by means of keys and a LCD graphic display.
- 10.8.3. Access to control and configuration of the unit by means of a password (edit MODE).
- 10.8.4. The signals given by the permanent indicators shall guarantee maximum reliability.
- 10.8.5. Indication shall be available directly on display on request of the user for not less than 48 hours even without an auxiliary voltage and batteries and also be given in the case of re-losing on a fault. After 48 hours of inactivity the information shall be retrievable by external devices. Indication shall contain at least the protection tripped.
- 10.8.6. It shall be possible to read the current values and information on the last 10 measures (current values, protection tripped) at any time through external devices, some of which can transmit data via bluetooth;
- 10.8.7. In the event of CB tripped, shall be indicated the type of protective function that intervened.
- 10.8.8. Each alarm or warning alarm shall be clearly shown on the display, when it is active.
- 10.8.9. On the protection release two (2) led's shall be present.
- 10.8.10. Warning LED shall be in place indicating at least the following:
 - Presence of one or more phases with current values in the $0.9 \cdot I_n < I < 1.05 \cdot I_n$ range
 - Presence, between two or three phases, of unbalance higher than the value programmed during configuration
 - The first temperature threshold of $T=70$ °C has been exceeded
 - Contact wear > 80%
 - Harmonic distortion
 - Out of range frequency
 - Breaker status error
 - Warning threshold override



- 10.8.11. Alarm LED shall be in place indicating at least following:
- Presence of one or more phases under overload with current values $I > 1,3 \cdot I_n$ (Overload Protection - L under timing)
 - Timing in progress for protection function S (Selective short circuit protection)
 - Timing in progress for protection function G (Earth fault protection)
 - The second temperature threshold of $T=85\text{ }^\circ\text{C}$ has been exceeded
 - Contact wear 100%.
 - Timing in progress for protection function D;
 - Timing in progress for protection function UV(Under Voltage), OV(Over Voltage), RV (Residual Voltage);
 - Timing in progress for protection function RP(Reversal of Active Power);
 - Timing in progress for protection function
 - Timing in case of unbalance between the phases higher than the value set during configuration with trip set to ON;
 - Current Sensors disconnected;
 - Opening solenoid (Trip Coil) disconnected
- 10.8.12. The communication function shall be implemented on the release by means of:
- An internal bus, with interface RS485;
 - An external bus, with Modbus RS485 protocol 2-Wire Twisted Pair, 19.2 kbit/s max.
- 10.8.13. There shall be the possibility of setting the release in remote and in local operating mode, and with the latter it shall not be possible to carry out data transmission from the system to the release. It shall be possible to automatically set the local mode by means of an external contact. An 24VDC auxiliary supply shall be used.
- 10.8.14. The protection release shall be able to send to the system these data:
Protection parameters set, phase and neutral currents, state of the circuit-breaker (open closed), position of the circuit-breaker (connected-isolated), state of the springs (charged discharged), number of circuit-breaker mechanical operations, total and for each protection number of trips, last interrupted current, contact wear, state of the protection functions (pre alarm function. L, timing function. L, S,G...), overtemperature protection function, state of internal communication bus.
- 10.8.15. The system shall transmit to the protection release the following data: protection parameters, circuit-breaker opening and closing commands, reset for tripping of some protection functions.
- 10.8.16. Adjustable inverse definite minimum time (IDMT) overcurrent release facilities are required in addition to the instantaneous fault trip for the air circuit breakers.

11. MOULDED CASE CIRCUIT BREAKERS (MCCB) SHALL CONFORM TO THE FOLLOWING CHARACTERISTICS.

11.1. Functional Characteristics

11.1.1. AC rated service voltage for currents over 160 A: 690 V AC (50-60 Hz).

11.1.2. DC rated service voltage: 500 V DC for currents of 160 A and 750 V DC for currents over 160A.

- 11.1.3. Rated uninterrupted current for 1000 V AC or DC applications: 800 A (three and four poles).
- 11.1.4. Minimum rated insulation voltage for currents equal or over 160 A: 8 kV.
- 11.1.5. Rated insulation voltage for currents equal or over 160 A: 800 V AC.
- 11.1.6. Rated uninterrupted current between 160 and 3200 A with trip units settings starting from 1A.
- 11.1.7. According to IEC 60947-2 (§ 4.4) starting from 400 A the circuit breakers shall be category B
- 11.1.8. MCCBs shall be available with different ultimate short breaking capacities between 16kA and 200kA @ 380/415 V AC.
- 11.1.9. Both line up and line down supplying shall be possible without decreasing MCCBs performances or functionality
- 11.1.10. For rated uninterrupted currents up to 160 A, the MCCB limiting features shall be enough to assure its conformity to IEC 60439-1 (§ 8.2.3.1) once installed into a type AS or ANS switchboard as general breakers. This shall be valid up to the MCCB's rated uninterrupted current (limiting versions are excluded).
- 11.1.11. A test bottom for the correct functionality checking (moving contacts opening) shall be placed in front of the breaker.

11.2. Ambient Characteristics

- 11.2.1. Operating temperature: -25 °C. +70 °C (ambient temperature)
- 11.2.2. Storage temperature: -40 °C .. +70 °C (ambient temperature)
- 11.2.3. Reference temperature for setting the thermal element of the thermomagnetic trip unit: +40 °C
- 11.2.4. Maximum relative humidity: 98%
- 11.2.5. Maximum altitude: 2000 m above sea level, 5000 m above sea level with derating suitability for being used in hot-humid places. With regard to this, the circuit-breakers shall undergo a tropicalization process to make them suitable for use in hot-humid places, as established in the prescriptions of the major naval registers and in compliance with the International IEC 60068-2-30 Standards.
- 11.2.6. Circuit-breakers fitted with electronic trip units shall comply with the prescriptions of the International Standards on electromagnetic compatibility.

11.3. Construction Characteristics

- 11.3.1. The range of moulded case circuit-breakers shall cover a range of rated uninterrupted currents from 160 to 3200 A
- 11.3.2. By means of the double insulation technique, moulded case circuit-breakers shall guarantee complete separation between the power circuits and the auxiliary circuits.
- 11.3.3. Moulded case circuit-breakers shall have an operating lever which always indicates the exact position of the circuit-breaker contacts (positive operation), by means of safe and reliable signals (I= closed, O= open, yellow-green line= open due to trip unit).



- 11.3.4. The operating mechanism shall be designed to operate all poles of the circuit breaker simultaneously for making, breaking and tripping.
- 11.3.5. Moulded case circuit-breakers shall be suitable for isolation in compliance with § 7.2.7 of the IEC 60947-2 Standard. This indication shall be clearly and indelibly marked on the circuit-breaker (in accordance with § 5.2 of IEC 60947-2) and in a position where it is visible with the circuit-breaker installed.
- 11.3.6. Moulded case circuit-breakers shall be available in the three-pole and four-pole version both in the fixed, and in any possible plug-in or withdrawable versions.
- 11.3.7. Circuit-breakers in the plug-in version starting from 250 A shall be available. In the case of a plug-in or withdrawable version, the presence of a device shall prevent racking-in or racking-out with the apparatus closed.
- 11.3.8. In the withdrawable version, racking-out with the door closed shall be possible.
- 11.3.9. The same depth and installation on a DIN EN 50022 rail shall be guaranteed up to the rated setting of 250 A inclusive. The same depth shall be guaranteed. This characteristic shall allow the switchboard and their support structures to be standardized.
- 11.3.10. Moulded case circuit-breakers with rated uninterrupted current up to 250 A shall have a 45 mm high face which makes them suitable for installation on modular panels.
- 11.3.11. All the installation positions shall be possible without jeopardizing the function of the apparatus. Starting from 630 A up to 1600 A the withdrawable version shall be mounted and operated horizontally.
- 11.3.12. For the front parts of the circuit-breakers the degree of protection of at least IP20 (excluding the terminals) shall be guaranteed, IP30 when they are installed in switchboards, and up to IP54 for circuit-breakers installed in a switchboard fitted with transmitted rotary handle and special accessory.

11.4. Protection Trip Units

- 11.4.1. Moulded case circuit-breakers shall be equipped with interchangeable trip units. From 160 A up to 800 A it shall be possible to choose between a thermomagnetic and an electronic protection. For the sizes higher than 800 A, the trip unit shall only be electronic. The trip unit shall be integrated in the volume of the apparatus.
- 11.4.2. From the 250 A size circuit-breakers, the trip unit shall be interchangeable. Trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorised access to the settings

11.5. Thermomagnetic Overcurrent Trip Units

- 11.5.1. Thermomagnetic trip units shall be fitted with protection threshold against overload (whose thermal element shall consist of a bimetal) and with protection threshold against short circuit.
- 11.5.2. The protection threshold against overload shall be continuously adjustable starting from 0.7 times the rated current of the trip unit and up to its rated value.
- 11.5.3. The reference temperature for setting the thermal element of the protection trip unit is 40°C.



- 11.5.4. The temperature performance of the trip unit shall be indicated as the temperature varies.
- 11.5.5. The protection threshold against short-circuit shall be either the fixed or adjustable type with continuity from 5 and up to 10 times the rated current of the trip unit. In the four-pole version, the neutral pole shall always be protected. For current values equal to or higher than 125 A, protection of the neutral pole shall, at choice, be at 100% or at 50% of the rated current of the trip unit. Vice versa, for current values of less than 125 A, protection of the neutral pole shall always be 100%.
- 11.5.6. For circuit-breakers with rated uninterrupted current of 160 A, 250 A, 400 A and 500A, a thermomagnetic trip unit shall be available for generator protection with adjustable thermal threshold, starting from $0.7 \times I_n$, and fixed magnetic threshold at $3 \times I_n$ or adjustable magnetic threshold from 2.5 to $5 \times I_n$. Suitability for use in direct current.

11.6. Magnetic only overcurrent trip units

- 11.6.1. The overcurrent trip units with magnetic only threshold shall be suitable for protection against short-circuit.
- 11.6.2. The adjustable magnetic only trip units (suitable for motor protection) shall only be available in the three-pole version, whereas those with fixed threshold shall also be available in the four-pole version.
- 11.6.3. The adjustable magnetic only trip units shall be available for circuit-breakers up to 320 A. Suitability for use in direct current.

11.7. Electronic Overcurrent Release Trip Units

- 11.7.1. The electronic overcurrent trip units shall be self-supplied and shall be able to guarantee correct operation of the protection functions even in the presence of a single phase supplied with a current value equal to 20% of the phase current. They shall be unaffected by electromagnetic interference in compliance with the EMC directive on the matter.
- 11.7.2. The basic version shall be fitted with protection functions against overload (function L) and against short-circuit. The latter function can either be of the instantaneous type (function I) or, alternatively, with intentional delay selective short circuit protection (function S). The function of protection against short circuit shall be excludable.
- 11.7.3. A basic version shall also be provided with only the protection threshold against instantaneous short-circuit which cannot be excluded.
- 11.7.4. The complete version shall be fitted with protection threshold against overload (function L), against instantaneous short-circuit (function I) and with intentional delay (function S) and also with protection threshold against earth fault (function G). All the protection functions except for protection against overload shall be excludable.
- 11.7.5. The advanced version shall be suited for zone selectivity protection for the S and G protection functions. An integrated ammeter and many other additional features are provided over and above the protection functions. All the protection functions except for protection against overload shall be excludable.
- 11.7.6. The advanced version shall be suited for zone selectivity protection for the S and G protection



functions. An integrated ammeter and many other additional features are provided over and above the protection functions. All the protection functions except for protection against overload shall be excludable.

- 11.7.7. A version dedicated to ultra rapid short-circuit protection (with a detection time less than 5 ms) combined with zone selectivity shall be available.
 - 11.7.8. An advanced version dedicated to motor protection shall be available with protection functions against overload (function L), against instantaneous short circuit (function I), against unbalanced or missing phase (function U) and against rotor block (function R).
 - 11.7.9. A version dedicated to generator protection shall be available (up to 160A), with protection functions against overload (function L), against instantaneous short circuit (function I) and with intentional delay (function S). The S and I protection functions are not an alternative to each other. All these functions are imposed by the major naval registers.
 - 11.7.10. All the advanced trip units shall be available with thermal memory.
 - 11.7.11. All the protection functions shall be characterized by threshold and time tolerances according to the International Standards.
 - 11.7.12. The trip unit shall allow parameterization of the trip thresholds and timing locally or remotely; in the case of any anomalies in remote parameterization, the protection shall automatically use the series of parameters set manually on the front of the circuit breaker.
 - 11.7.13. On the advanced version, access to information and programming shall be allowed by a keyboard and graphic liquid crystal display.
 - 11.7.14. Alarm signals for the protection functions will be available by means of LEDs located on the trip unit (complete version) and/or on the display (advanced version).
 - 11.7.15. The size of the current sensors shall be a minimum of 10 A to a maximum of 3200 A so as to cover the widest possible current range.
 - 11.7.16. Interchangeable rating-plugs shall be available starting from 400 A.
 - 11.7.17. The four-pole circuit-breaker shall always be supplied with the neutral protected at 100% up to 125A excluded, and for higher values with protection selected between 50% and 100% of the rated current of the trip unit. Starting from 630A setting of the neutral at 150% and 200% shall be possible.
 - 11.7.18. The current sensors for external neutral shall be optional.
 - 11.7.19. Moulded Case Circuit breakers equipped with electronic releases shall be available a dedicated function to verify the correct connection between the trip unit, current sensor and trip coil. Eventual anomalies shall be signalled by a red led flashing.
- 11.8. Accessories for electronic trip units shall be available, such as the test unit for checking functioning of the tripping coil of the electronic trip unit, a trip signalling unit of the protections, a test and configuration unit which allows the electronic trip unit protections to be tested and configured, an actuation unit which allows circuit-breaker opening and closing by means of a motor operator



mounted on it, a battery unit which allows trip unit testing when the circuit-breaker and an external unit for wireless communication.

- 11.8.1. For both the complete and the advanced version a measurement module shall be available, in order to gauge the plant functioning parameters, such as phase and phase to phase voltages, powers and energies. On the advanced version all the available measurements can be displayed on the LCD. Furthermore, for the electronic trip units for motor protection, there shall also be a contactor control unit available.
- 11.8.2. The advanced version will be provided with a data logger function that automatically records and stores the instantaneous values of all the currents and voltages. Data shall be easily downloaded to any personal computer for elaboration. The data logger function freezes the recording whenever a trip occurs, so that a detailed analysis of faults can be easily performed. The sampling rate shall be adjustable up to 4800Hz, with total sampling time up to 27 s (@ 600Hz sampling rate). Tracking of up to 64 events shall be possible.

11.9. Protections

The minimum performances of the protection functions of the electronic protection trip unit for distribution, where present, shall be:

- 11.9.1. Function L: adjustable trip threshold $I1 = (0.4-1) \times I_n$, trip curves for the basic version with time settings from 3 to 12 seconds – 2 different trip curves - (at 6 times the set threshold), whereas for the advanced version with time settings from 3 to 18 seconds – 4 different trip curves - (at 6 times the set threshold). For the advanced version, L function according to IEC 60255-3 shall be available. *Cannot be excluded.*
- 11.9.2. Function S: adjustable trip threshold $I2 = (1-10) \times I_n$, trip curves for the basic version with time settings from 0.1 to 0.25 seconds – 2 different trip curves – (at 8 times the rated current of the trip unit), whereas for the advanced version with time settings from 0.05 to 0.5 seconds – 4 different trip curves with inverse short time with definite time characteristic or curves with definite time – (at 6 times the rated current of the trip unit). For circuit breakers from 250 A to 630 A, in the advanced version, $I2 = (0.6-10) \times I_n$. *Can be excluded.*
- 11.9.3. Function I: adjustable trip threshold $I3 = (1-10) \times I_n$ for the basic version (instantaneous trip), whereas for the advanced version $I3 = (1.5-15) \times I_n$ (instantaneous trip). *Can be excluded.*
- 11.9.4. Function G: adjustable trip threshold $I4 = (0.2-1) \times I_n$ with trip time settings from 0.1 to 0.8 s with curve with inverse short time and definite time characteristic. *Can be excluded.*
- 11.9.5. Function U: adjustable trip threshold $I6 = (2\% \dots 90\%) \times I1$ with trip time settings from 0.5 to 60 s with curve with inverse short time and definite time characteristic. *Can be excluded.*
- 11.9.6. Function OT: fixed at 85 °C (with instantaneous trip). *Can be excluded.*



- 11.9.7. Function UV: adjustable trip threshold $U8 = (0.5-0.95) \times U_n$ with trip time settings from 0.1 to 5 s with curve with inverse short time and definite time characteristic. *Can be excluded.*
- 11.9.8. Function OV: adjustable trip threshold $U9 = (1.05-1.2) \times U_n$ with trip time settings from 0.1 to 5 s with curve with inverse short time and definite time characteristic. *Can be excluded.*
- 11.9.9. Function RV: adjustable trip threshold $U10 = (0.1-0.4) \times U_n$ with trip time settings from 0.5 to 30 s with curve with inverse short time and definite time characteristic. *Can be excluded.*
- 11.9.10. Function RP: adjustable trip threshold $P11 = (-0.3...-0.1) \times P_n$ with trip time settings from 0.5 to 25 s with curve with inverse short time and definite time characteristic. *Can be excluded.*
- 11.9.11. Function UF: adjustable trip threshold $f12 = (0.9-0.99) \times f_n$ with trip time settings from 0.5 to 3sec with curve with inverse short time and definite time characteristic. *Can be excluded.*
- 11.9.12. Function OF: adjustable trip threshold $f13 = (1.01-1.10) \times f_n$ with trip time settings from 0.5 to 3 s with curve with inverse short time and definite time characteristic. *Can be excluded.*
- 11.9.13. The minimum performances of the protection functions of the electronic protection trip unit for motor protection shall be:
- Function L: adjustable trip threshold $I1 = (0.4-1) \times I_n$, trip curves in class 10A, 10, 20 and 30 or 3E, 5E, 10E e 20E in compliance with the IEC 60947-4-1 Standard, with temperature compensation and sensitivity to missing/unbalanced phase. *Cannot be excluded.*
 - Function R: adjustable trip threshold $I5 = (3-10) \times I1 + \text{OFF}$, with 4 different trip curves with definite time with time settings $t5 = 1...10$ s. Automatic exclusion of the function during the motor starting phase, and automatically reactivated after this. *Can be excluded.*
 - Function I: adjustable trip threshold $I3 = (6-13) \times I_n$ (instantaneous trip) with recognition of the motor starting phase.
 - Function U: adjustable trip threshold $I6 = (0.4-0.9) \times I1$ e $t6 = 4$ s. *Can be excluded.*
 - Possibility of contactor control for trip of functions L and R.
 - Possibility of connection to a PTC (temperature probe) inserted in the motor.

11.10. Dialogue

For circuit-breakers from 250 A to 1600 A dialogue shall be available, making the following functions possible:

- 11.10.1. Remote setting of the protection function parameters, unit configuration and communication.

- 11.10.2. Transmission of measurements, states and alarms from circuit-breaker to system transmission of events to the system.
- 11.10.3. Dialogue units able to support different standard market protocols shall be available:
 - 11.10.3.1. Modbus RTU protocol, EIA RS485 physical transmission means, speed 9.6...19,2 Kbit/s, bus architecture.
 - 11.10.3.2. Profibus DP protocol, RS485 physical transmission, speed 9.6...19,2 Kbit/s, bus architecture.
 - 11.10.3.3. Device Net protocol, RS485 physical transmission, speed 9.6...19,2 Kbit/s, bus architecture. Wireless bluetooth protocol.
 - 11.10.3.4. The dialogue unit shall make all the parameterization and measurement information of the protection unit available on the field bus, as well as the state of the circuit-breaker (open/closed, racked-in/racked-out) and of the related trip units. Shall be providing a tool able to analyse all these data by PC.

11.11. Accessories

11.11.1. Electrical Accessories

- 11.11.1.1. Internal Accessories has to be the same up to 250A as well from 250A to 1000A.
- 11.11.1.2. Auxiliary contacts: these shall allow the state of the circuit-breaker (open or closed; contact on change-over) and trip unit to be known. Auxiliary contacts for use at 250 V AC/DC, 400V AC and 24 V DC (digital contacts) shall be available.
- 11.11.1.3. Releases: the shunt opening and under-voltage releases shall be available with different power supply voltages both in AC and DC.
- 11.11.1.4. With circuit-breakers up to 250 A the electrical accessories shall be available both in the pre- cabled version and with 1m long un-cabled cables.
- 11.11.1.5. The addition of the electrical accessories shall not increase the volume of the circuit breakers.

11.11.2. Mechanical Accessories

- 11.11.2.1. Terminals: different types of terminals (both front and rear) shall be available for all the sizes, suitable for connection with copper, copper-aluminium cable and bus bar connections.
- 11.11.2.2. Up to the 160 A size, the circuit-breakers can be fitted with different types of terminals combined in different ways (higher of one type, lower of a different type). Terminal covers and phase separators shall also be available.
- 11.11.2.3. Multi-cable terminals shall be available for circuit-breakers for the 250-320-400-630 A size. Support for fixing onto DIN rail: supports for fixing onto DIN EN 50022 rail shall be available up to the rated current of 250 A inclusive.
- 11.11.2.4. Mechanical interlocks: mechanical interlocks shall be available for the whole series of circuit-breakers; the interlock can be of the front type for circuit-breakers with rated



current up to 250 A. It shall be possible to interlock circuit-breakers of different sizes at least up to 250 A and between 250A and 630 A.

11.11.2.5. Rotary handle: a rotary handle operating mechanism both in the direct and transmitted version shall be available for the whole range of circuit-breakers, both padlockable in the open position and fitted, on request, with the following accessories: early contact for under-voltage release, compartment door lock and key lock in open position.

11.11.2.6. The whole range of moulded case circuit-breakers shall be fitted with motor operator (according to the rated current of the circuit-breaker, this can either be of the solenoid type, or with stored energy) for remote operation of the circuit-breaker.

11.12. Residual Current Release

11.12.1. General Aspects

11.12.1.1. The residual current releases used in low voltage installations shall be designed, constructed and tested in compliance with the International Standards and in particular with:

11.12.1.1.1. IEC 60947-2 appendix B and ANNEX M

11.12.1.1.2. IEC 60255-4 and IEC 61000: for protection against unwarranted trips

11.12.1.1.3. IEC 60755 for insensitivity to the continuous current components

11.12.1.2. It shall be possible to install the residual current releases in installations with line-to-line voltage up to 690 V.

11.12.1.3. They shall be able to be used in close connection with circuit-breakers and/or switch disconnectors.

11.12.1.4. Shall be guaranteed the normal operating up to -25°C

11.13. Construction Characteristics

11.13.1. It shall be possible to combine the range of residual current releases with all the circuit breakers making up the range of moulded case circuit-breakers so as to cover the whole current range of MCCBs.

11.13.2. It shall be possible to combine the residual current releases with circuit-breakers in fixed, plug-in and withdrawable version.

11.13.3. Their installation on a DIN rail shall be possible.

11.13.4. Control of correct operation shall be possible according to the prescriptions of the reference Standards, by means of a test pushbutton on the front of the apparatus.

11.13.5. Residual current releases shall be available both in the three-pole up to 250A and in the four-pole version.

11.13.6. Dedicated residual current releases shall be available up to 1600 A

11.13.7. Type B residual current protection shall be available



- 11.13.8. It shall be possible to select the maximum threshold of sensitivity to the residual current fault frequency (3 steps: 400 700 1000 Hz).

11.14. Electrical Characteristics and Performances

- 11.14.1. Up to the rated current of 250 A, the service voltage shall be between 85 and 500 V AC line-to-line (operation up to 50 V phase-neutral). Trip thresholds I_{dn} starting from 0.03A and up to 10 A shall also be available for the advanced version which shall also allow selection of the trip times (for the basic version, the trip shall be of the instantaneous type).
- 11.14.2. A contact signalling pre-alarm shall be available in the advanced version and the availability of an input for remote opening.
- 11.14.3. There shall be type A versions for alternating pulsed current, S selective and E for emergency stop of the residual current release.
- 11.14.4. The release shall be self-supplied and the power supply can come either from above or below.
- 11.14.5. Compliance with the International Standards on the matter of electromagnetic compatibility.
- 11.14.6. There shall be a switchboard residual current unit with voltage varying between 80 and 500 V AC and between 48 and 125 V DC. There shall be availability of several adjustment ranges from 0.03 to 30 A, with trip times from instantaneous to 5 s and pre-alarm threshold adjustment.
- 11.14.7. The toroidal transformers can either be closed (from 60 to 180 mm in diameter) or open (from 110 to 230 mm in diameter).

12. MINIATURE CIRCUIT BREAKERS SHALL CONFORM TO THE FOLLOWING CHARACTERISTICS.

12.1. Functional Characteristics (1 to 63 Amps)

- 12.1.1. Miniature Circuit Breaker for cable protection according to:
DIN VDE 0641 Teil 11,
EN 60898, IEC 60947-2, EN 60947-2,
UL1077/C22.2 No.235, UL489/C22.2 No.5
- 12.1.2. Rated short-circuit capacity I_{cn} shall be: 6/10/25 kA unless otherwise indicated.

12.2. Tripping Characteristics/curves shall be as follows

B: In 6/10/13/16/20/25/32/40/50/63 A
C: In 0,5/1/1,6/2/3/4/6/8/10/13/16/20/25/32/40/50/63 A
K: In 0,2/0,5/1/1,6/2/3/4/6/8/10/13/16/20/25/32/40/50/63 A
Z: In 0,5/1/1,6/2/3/4/6/8/10/16/20/25/32/40/50/63 A
Number of poles: 1/2/3/4/1+NA/3+NA
Energy Limiting Class: 3
Rated Voltage U_n :
Single-pole: 230/400 VAC
Multi-pole: 400VAC
Max. Operating Voltage $U_{Bmax DC}$:
Single Pole: 72 VDC

Double Pole: 125 VDC
Suitable for isolation acc. IEC 60898-1

12.3. Environmental Characteristics

- 12.3.1. Operating temperature: -25 °C...+70 °C and storage temperature: -40 °C...+70 °C.
- 12.3.2. Altitude: operation without derating up to 2000 m (6600 ft), and with derating up to 4000 m.
- 12.3.3. Suitability for use in a hot-humid environment. With regard to this, the circuit-breakers shall undergo a tropicalisation process which makes them suitable for use in a hot humid environment, as established by the prescriptions of the main shipping registers and in accordance with the international IEC 60068-2-30 Standards.

12.4. Construction Characteristics

- 12.4.1. Guide edge for labels
- 12.4.2. Prepared for locking devices
- 12.4.3. Quick and easy removal of installed device

12.5. Wiring

- 12.5.1. Busbars: Terminals for in and out coming feeder on top of busbars. The MCB shall have a "safe terminal". Each pole shall have 2 connection points. Combining busbar and wire in same terminal shall not be permitted. Combining wire of un-equal sizes in the same terminal shall not be permitted.

12.6. Accessories

- 12.6.1. Retrofit accessories (extract):
 - Universal signal contact/auxiliary contact (right): 1SO
 - Auxiliary contact (right): 1SO
 - Auxiliary contact (left): 1NO/1NC, 2NO or 2NC
 - Bottom-fitting auxiliary contact: 1NO or 1NC (bottom fitted without increasing width of MCB)
 - Undervoltage- or Shunt trip release
 - Hand operated neutral
 - Motor operating device (remote control)
 - DDA-Block
 - Labelling system (marked or blank)
 - Locking devices

12.7. Functional Characteristics (80 to 100 Amps)

- 12.7.1. Miniature Circuit Breaker for cable protection according to:
DIN VDE 0641 Teil 11, DIN VDE 0660 Teil 101, IEC 60898, EN 60898, IEC 60947-2, EN 60947-2
- 12.7.2. Rated short-circuit capacity shall be minimum: 6 kA unless otherwise stated.

12.8. Tripping Characteristics

- 12.8.1. B mit In 80/100 A

C mit In 80/100 A
Number of poles: 1/2/3/4
Energy Limiting Class: 3
Rated Voltage:
Single-pole: 230 VAC and 60 VDC
Single-pole: 400 VAC and 125 VDC
Suitable for isolation acc.: IEC 60947-1/-3

12.9. General Features

- 12.9.1. Label holder
- 12.9.2. Prepared to get equipped with toggle-locking device

12.10. Wiring

- 12.10.1. Busbars: Terminals for in and out coming feeder on top of busbars. The MCB shall have a "safe terminal". Each pole shall have 2 connection points. Combining busbar and wire in same terminal shall not be permitted. Combining wire of un-equal sizes in the same terminal shall not be permitted.

12.11. Accessories

- 12.11.1. Auxiliary contact: 2 or 3 contacts (screw-able or push-in-able)
- 12.11.2. Auxiliary contact (low power): 1 or 3 contacts
- 12.11.3. Signal contact or signal contact/auxiliary contact: 3 contacts
- 12.11.4. Undervoltage release or shunt trip
- 12.11.5. Neutral conductor
- 12.11.6. Printed labels
- 12.11.7. Labels for individual printing
- 12.11.8. Locking devices

12.12. Functional Characteristics (DC Protection)

- 12.12.1. Miniature Circuit Breaker for cable protection according to: DIN VDE 0641 Teil 12, DIN VDE 0660 Teil 101, IEC 60898, EN 60898, IEC 60947-2, EN 60947-2, UL1077
- 12.12.2. Rated short-circuit capacity: 4,5/6 kA

12.13. Tripping characteristics shall conform to the following

B: In 6/10/16/20/25 A
K: In 0,2/0,3/0,5/0,75/1/1,6/2/3/4/6/8/10/16/20/25/32/40/50/63 A
In 0,5/1/1,6/2/3/4/6/8/10/16/20/25/32/40/50/63A
Number of poles: 1/2/3/4 (K,Z); 1/2 (B)

Rated Voltage:

Single-pole: 230/400 VAC and 220 VDC

Multi-pole: 400 VAC and 440 VDC

Suitable for isolation acc: IEC 60947-1/-3

12.14. General Features

12.14.1. Label holder

12.14.2. Prepared to get equipped with toggle-locking device

12.15. Wiring

12.15.1. Busbars: Terminals for in and out coming feeder on top of busbars. The MCB shall have a "safe terminal". Each pole shall have 2 connection points. Combining busbar and wire in same terminal shall not be permitted. Combining wire of un-equal sizes in the same terminal shall not be permitted.

12.16. Accessories

12.16.1. Auxiliary contact: 2 or 3 contacts shall be (screw-able or push-in-able)

12.16.2. Auxiliary contact (low power): 1 or 3 contacts

12.16.3. Signal contact or signal contact/auxiliary contact: 3 contacts

12.16.4. Undervoltage release or shunt trip

12.16.5. Neutral conductor

12.16.6. Printed labels

12.16.7. Labels for individual printing

12.16.8. Locking devices

13. CONTACTORS

13.1. Contactors shall comply with SANS 60947. Duty cycle shall be AC3. Contactor coil voltage may be either 230V or 400V unless otherwise stated.

13.2. Lighting contactors for 24 to 63 Amps (AC1) shall be DIN mounted on the same rail as the MCBs and feature a DC solenoid actuator and are thus hum-free. They shall have a switching position indicator, integrated coil protection circuits and overvoltage protection for the solenoid coil up to 5kV.

13.3. Contactors from 9 to 38 Amps shall be electronic coils.

13.4. For contactors from 50 to 300 Amps, standard coils will be accepted.

13.5. Contactors from 400 to 2050 Amps shall be electronic coils.

13.6. Mixture of contactors shall not be permitted.

13.7. Ambient characteristics

13.7.1. Climatic withstand according to IEC60068-2-0 AND 60068-2-11

13.8. Construction characteristics

13.8.1. Contactors with electronic coils 9 to 38 Amps AC3 shall have:

13.8.1.1. Maximum of two frame sizes from 9 to 16 amps AC3

13.8.1.2. Width not to exceed 45mm for contactors 9 to 38 amps AC3 rating

13.8.1.3. Contactor up to 16 amps to include built in auxiliary contact

13.8.1.4. Common auxiliaries for contactors 9 to 38 amps AC3

13.8.2. Contactors 9 to 110 Amps with standard coil shall have:

13.8.2.1. Mounting positions: only position 6 not permitted (see appendix 1)

13.8.2.2. Maximum of 4 frame sizes from 9 to 110 amps

13.8.2.3. Quick fixing on mounting rail according to IEC 60715 standards as:-

- 35 x 7.5 mm for 9 to 40 amps contactors
- 35 x 15 mm for 9 to 75 amps contactors
- 75 x 25 mm for 50 to 110 amps contactors
- Terminal with captive screws
- Terminal screws to be of Pozidriv type up to 75 amps AC3
- Terminal screws to be M8 Hexagon socket for main terminals and Pozidriv for coil terminals

13.8.3. Contactors 145 to 750 Amps AC3 with Standard or Electronic Coil shall have:

13.8.3.1. Maximum of 4 frame sizes from 145 amp to 750 amp

13.8.3.2. Mechanical design to incorporate power terminal at base of contactor, operating coil to be mounted on top of contactor. Coil removal to side of contactor shall not be permitted.

13.8.3.3. Shall have front access to coil , with no need to remove the power cables when changing coils

13.8.3.4. Shall have front access to main fixed and moving contacts , without the need to remove the power cables

13.8.3.5. Removal and replacement of the fixed and moving contacts shall be able to be accomplished without the need to remove the power cables

13.8.3.6. Contactor shall have quick release quarter turn screws for easy access to main contact inspection

13.8.3.7. Clear marking of contactor electrical information, marking to be clearly visible on front of contactor

13.8.3.8. Electrical characteristics and performances

- 13.8.3.8.1. All Contactors shall be electrically coordinated with upstream protection device, whether device or the fuse type, MCCB, or manual motor starter. All coordination to be backed up by Manufactures coordination tables, available on request.

13.8.4. Contactors with electronic coils 9 to 38 Amps AC3

- 13.8.4.1. Same coil to cover both the AC or DC control supplies
- 13.8.4.2. Coil to be of torroidal design
- 13.8.4.3. Coil to have extended voltage operating limits.
- 13.8.4.4. 4 coil types only covering: 24..500 V 50/60Hz and 20..500 V DC
- 13.8.4.5. Coil Consumption not to exceed the following limits
- 13.8.4.6. On pull in 50VA
- 13.8.4.7. On holding 2.2VA
- 13.8.4.8. Built-in surge protection to be incorporated
- 13.8.4.9. Flexible position of Coil terminals i.e. can be transferred from the top to the bottom of contactor
- 13.8.4.10. With additional coil terminal block, it shall be possible to connect the coil both at the top and at the bottom.

13.8.5. Contactors with standard AC coil 50 to 30 Amps AC3 shall have:

- 13.8.5.1. Rated operational voltage 690V for contactors up to 40 amp AC3
- 13.8.5.2. Rated operational voltage 1000V for contactors 50 to 750 amps AC3.
- 13.8.5.3. Rated making capacity to be equal to 10 x AC3 rated operational current, or greater.
- 13.8.5.4. Rated breaking capacity to be equal to 8 x AC3 rated operational current, or greater.
- 13.8.5.5. Coil operating limits (according to IEC60947-4-1) 0.851.1 x rated Control circuit voltage, at temperature less or equal to 55degrees Celsius
- 13.8.5.6. Drop out voltage in %age of rated Control Voltage approximately 40 to 65%
- 13.8.5.7. Contactors 400 amp AC3 upward to incorporate electronic coil technology

13.8.6. Contactors with electronic coils 400 to 750 Amps AC3 shall have:

- 13.8.6.1. As above but to include the following
- 13.8.6.2. Same coil to cover both the AC or DC control supplies
- 13.8.6.3. Coil to have extended voltage operating limits.

- 13.8.6.4. Can withstand voltage interruptions or voltage dips in control supply up to 20ms.
- 13.8.6.5. Distinct opening and closing voltages as follows
- 13.8.6.6. Opening 0.55 x min operating voltage
- 13.8.6.7. Closing 0.85 x min operating voltage
- 13.8.6.8. Coil types only covering: 24..500 V 50/60Hz and 20..500 V DC

13.9. Accessories

- 13.9.1. All auxiliary contacts shall employ the “wipe action” mechanism for the self cleaning of the contact tips.
- 13.9.2. Front mounted auxiliary contact blocks rated insulation voltage equal to 690V a.c or greater
- 13.9.3. Rated operation voltage 24...690VAC
- 13.9.4. Rated making capacity 10 x AC-15 rated operational current
- 13.9.5. Rated breaking capacity 10 x AC-15 rated operational current
- 13.9.6. Rated short time withstand current 100amps for 1sec.;, 140 amps for 0.1 sec
- 13.9.7. Electrical durability, max electrical switching frequency 1200 cycles per hour or greater

13.10. Side Mount Auxiliary Contact Blocks shall have:

- 13.10.1. Rated insulation voltage equal to 690V a.c or greater
- 13.10.2. Rated operation voltage 24...690V a.c
- 13.10.3. Rated making capacity 10 x AC-15 rated operational current
- 13.10.4. Rated breaking capacity 10 x AC-15 rated operational current
- 13.10.5. Rated short time withstand current 100amps for 1sec.;, 140 amps for 0.1 sec
- 13.10.6. Electrical durability, max electrical switching 1200 cycles per hour or greater.

14. LIGHTNING AND SURGE PROTECTION

14.1. Main Distribution Board

- 14.1.1. According to the IEC 62305 recommendations, electrical installations shall be protected against direct lightning and surge impulses with din rail Class 1/Type 1 (10/350µs) lightning current arresters.
- 14.1.2. SPD shall use a triggered spark gap technology to allow high lightning discharge current, unpluggable type to avoid ejection of the cartridge during the discharge of the current and non-blow out technology to avoid fire risks.
- 14.1.3. The SPD shall provide either common protection in TNC network or common and differential mode protection in TT and TNS network according to the IEC60364 recommendations.

14.1.4. Lightning arresters shall have the following technical specifications:

- 14.1.4.1. Class of test (IEC 61643-1) I
- 14.1.4.2. Lightning impulse current: $I_{imp}/pole (10/350\mu s) \geq 25kA$
- 14.1.4.3. Nominal voltage U_n 230 / 400V
- 14.1.4.4. Maximum continuous AC voltage U_c 255V
- 14.1.4.5. Follow current extinguishing capability $I_{fi} \geq 50kA$
- 14.1.4.6. Protection level U_p : 2.5kV
- 14.1.4.7. Max. back up fuse gG/gL: 125A
- 14.1.4.8. Visual state indicator: Yes

14.2. Sub-Main Distribution Board

- 14.2.1. According to the IEC 62305 recommendations to avoid oscillations and magnetic coupling phenomenon, sensible equipments shall be protected against indirect surges with din rail Class 2 / Type 2 (8/20 μs) surge arresters.
- 14.2.2. The SPD shall have a safety reserve system and shall be pluggable for preventive and easy maintenance. The SPD shall provide either common protection in TNC network or common and differential mode protection in TNS and TT network according to the IEC 60 364 recommendations.
- 14.2.3. In case of common and differential mode protection the SPD shall use an association of MOV and GDT to provide isolation to the ground and low protection level in all protection modes. The associated switching element
- 14.2.4. (MCB/Fuse) (to insure a safe end of life) shall be the same brand as the SPD to insure a good coordination.
- 14.2.5. Surge arresters technical specifications:
 - 14.2.5.1. Class of test (IEC 61643-1) II
 - 14.2.5.2. Max. discharge current: $I_{max}/pole (8/20\mu s) \geq 40kA$
 - 14.2.5.3. Nominal current I_n / pole $\geq 20kA$
 - 14.2.5.4. Nominal voltage U_n 230 / 400V
 - 14.2.5.5. Maximum continuous AC voltage U_c 275 / 255V
 - 14.2.5.6. Protection level U_p at 20kA ≤ 1.5 kV

- 14.2.5.7. Protection level Up at 3kA (Class 3 test)
- 14.2.5.8. Pluggable :Yes
- 14.2.5.9. Visual status indicator: Yes
- 14.2.5.10. Safety reserve: Yes
- 14.2.5.11. Remote indicator :Yes

14.3. Data line / Telecom line

- 14.3.1. The selection of the surge protection device shall be according the IEC 62305 recommendations and therefore shall be a type C2 SPD.
- 14.3.2. The SPD shall be pluggable type for easy maintenance and shall provide the dialling tone returns when the cartridge is withdrawn in case of end of life.
- 14.3.3. The cartridges, whatever the nominal voltage, shall be adaptable onto different base. The base shall be chosen according to the connection of the wire: it can be RJ11, RJ45 or screw connection. The connections to the earth shall be either by a DIN rail contact or by a screw terminal.
- 14.3.4. The SPD dimension shall not exceed 12.5 mm wide to save space. The SPD shall use two level of protection: the first one by GDT, the second one by zener diode. These two levels shall be coordinated and shall provide common and differential mode protection.
- 14.3.5. Low current surge arresters technical specifications:
 - 14.3.5.1. Class of test (IEC 61643-21): C2
 - 14.3.5.2. Nominal voltage U_n According to the Max.voltage of signal
 - 14.3.5.3. Maximum continuous AC voltage U_c (L-N / N-G): According to the Max. voltage of signal
 - 14.3.5.4. Loading current: 140mA
 - 14.3.5.5. Max. discharge current: $I_{max} / \text{line} (8/20\mu\text{s}) \geq 10\text{kA}$
 - 14.3.5.6. C2 Nominal discharge current $I_n / \text{line} (8/20\mu\text{s}) \geq 5\text{kA}$
 - 14.3.5.7. Protection level U_p (L-L / L-G): According to the Max. voltage of signal
 - 14.3.5.8. Pluggable: Yes

15. ANTI-CONDENSATION HEATERS

- 15.1. Anti-condensation 220 Volt heaters shall be provided for all compartments. A switch with thermostat shall be provided to control the heaters.
- 15.2. The wiring from the heater elements to terminals shall be high temperature insulation covered, a suitable compression type gland shall be fitted for the incoming 231V supply.

**16. INDICATING INSTRUMENTS**

- 16.1. A flush mounted, industrial grade, 96 mm square voltmeters and ammeter conforming to SABS 1299 shall be mounted near the centre top of the front panel and connected to measure the busbar voltage and current.
- 16.2. The calibrated scale length shall be a minimum of 70 mm. Means shall be provided for zero adjustment from the front without any dismantling of the indicating instrument.
- 16.3. A voltmeters selector switch with phase to phase, phase to neutral, and "off" position shall be provided.
- 16.4. An ammeter selector switch shall be provided with an "OFF" position.
- 16.5. Meters shall indicate by means of colours the relevant phase that it is metering.

17. CURRENT TRANSFORMERS

- 17.1. Current transformers shall comply with BS 3938.

18. MECHANICAL CABLE GLANDS

- 18.1. Cable glands shall be of the compression type, manufactured in brass and/or bronze, and suitable for termination of earth-continuity conductor type cables where applicable.
- 18.2. The gland body shall incorporate a knurled cone for clamping the armouring and an integrally cast earth lug, complete with earthing screw.
- 18.3. All metal portions of the gland shall be electroplated for corrosion resistance.
- 18.4. The glands shall be supplied complete with weatherproof neoprene shrouds.
- 18.5. Entries for multi-core PVC, PVC, wire armoured, PVC sheathed cables shall comprise cone grip mechanical type glands mounted on robust gland plates.
- 18.6. The board shall be supplied complete with all glands for all outgoing and incoming circuits as indicated on the drawing.

19. LIGHT SENSITIVE CONTROL UNIT

- 19.1. Light sensitive control units shall be supplied by others.
- 19.2. A suitably rated single pole over-riding switch, for over-riding the unit in 19.1, and moulded case circuit breaker shall be provided, when called for in the drawings or appendices hereto.
- 19.3. The switch and circuit breaker shall be wired to a suitable terminal strip, mounted within the distribution board, to facilitate connection of the light sensitive control unit when installed.

20. EARTHING

- 20.1. The components shall be effectively bonded to the main frame of the distribution board, which shall also be bonded to the main earth bar. Earthing shall comply with SANS-10142 code of practice for the wiring of premises.

21. CABLING AND WIRING

- 21.1. All cables and wires used shall be stranded, 600/1000 V grade and comply with SABS 150, except where special cables have been otherwise specified.

22. LABELS

- 22.1. Labels shall be provided comprising conspicuous engraved black lettering on white background secured with rivets or screws on or adjacent to the items concerned, and worded in English.
- 22.2. Labels of embossed tape or labels secured with adhesive are not acceptable.
- 22.3. All fuse-switches, circuit breakers, isolators, contactors, relays, etc., shall be clearly designated.
- 22.4. The terminals of all outgoing circuits shall be provided with labels to correspond with the labelling of the units on the panel of the distribution board.
- 22.5. All terminal connections shall be provided with durable tags or clips, on which shall be clearly and indelibly marked, the identifying code letters of each wire. Such code letters shall correspond to those used on the wiring diagram.

23. PAINTING

- 23.1. All surfaces of the distribution board shall be light orange to SABS 1091 colour No. B26. (Transnet orange; Pantone 165C / 021U; Coats 50/50; Vermilion MW52; RAL 2004 rein orange; Trichromatic 70% magenta, 90% yellow), unless otherwise specified.
- 23.2. All surfaces shall be cleaned according to the appropriate method described in SABS 064 for the particular surface to be cleaned, the contamination to be removed and the primer to be applied.
- 23.3. Blast cleaning of components shall be in accordance with clause 4.3 of SABS 064 to a degree of cleanliness of at least Sa2 for inland exposure components and Sa 1/2 for coastal exposure components. See Table 1 of SABS 064 for the appropriate profile.
- 23.4. Sheet metal that cannot be blast cleaned shall be cleaned by pickling according to clause 4.6 of SABS 064.
- 23.5. Components that shall be powder coated shall be cleaned and prepared by the surface conversion process according to clause 5 of SABS 064 to a medium-weight classification of table 2 of that specification.
- 23.6. Oil and accumulated dirt on steel components where no rusting is present shall be removed according to clause 3 of SABS 064.
- 23.7. The powder-coating process shall be in accordance with SANS 1242 - type 4 : Corrosion-resistant coatings for interior use and using the thermosetting type high gloss coating.
- 23.8. All specified coatings shall be applied according to the relevant specification and the manufacturer's instructions shall be followed.

- 23.9. Coatings shall not be applied under conditions that may be detrimental to the effectiveness of the coating or the appearance of the painted surface.
- 23.10. When examined visually the finished products shall have a uniform appearance as far as gloss is concerned and shall show no sign of damage. Damaged areas shall be repaired coat for coat to obtain the desired finish.

24. ADDITIONS AND MODIFICATIONS TO EXISTING DISTRIBUTION BOARDS

- 24.1. Where the contractor needs to make modifications or additions to existing distribution boards, the following minimum criteria shall be adhered to :
- 24.1.1. Re-labelling and proving of existing circuits in accordance with security of existing terminations to be confirmed
- 24.1.2. Isolation barriers, cover blanks to be in place where required
- 24.1.3. Panel modification in terms of architraves, DB covers, and the closing of redundant openings to be undertaken by an accredited switchboard manufacturer.
- 24.1.4. Wiring to be examined for integrity correct sizing and tidied and/or replaced and neatened as required.
- 24.1.5. A certificate of compliance shall be issued for the full distribution board and not the additions only.

25. INSPECTION

- 25.1. Transnet reserves the right to carry out inspection of any items of equipment and work at any time during the manufacture at manufacturer's works and to be present at any tests.
- 25.2. A final inspection by Transnet before delivery to site is required.

26. TESTS

- 26.1. All prescribed tests as referred to in the standard specifications may be called for at the discretion of Transnet.
- 26.2. Transnet also reserves the right to carry out any check tests on the equipment.
- 26.3. Notwithstanding the successful completion of tests, the tenderer shall still be responsible for the efficient operation of the equipment.
- 26.4. The tenderer shall bear all costs for any tests, which shall be required.

27. GUARANTEE

- 27.1. The Contractor shall undertake to repair all faults due to bad workmanship and / or faulty materials and to replace all defective apparatus or materials during a period of twelve (12) calendar months, calculated from the date of delivery.
- 27.2. Any defects that may become apparent during the guarantee period shall be rectified to the



satisfaction of, and free of cost.

- 27.3. The Contractor shall undertake work on the rectification of any defects that may arise during the guarantee period within 7 days of his being notified by Transnet of such defects.
- 27.4. Should the Contractor fail to comply with the requirements stipulated above, Transnet will be entitled to undertake the necessary repair work or effect replacement of defective apparatus or materials, and the Contractor shall reimburse Transnet the total cost of such repair or replacements, including the labour costs incurred in replacing defective material.

28. SPARES

- 28.1. The tenderer shall state whether a complete range of spares is held in stock by their local representatives for subsequent purchase by Transnet as and when required.



WITNESSES

1.

2.

**Transnet Port Terminals
Design Services**

.....
TENDERER


.....
DATE

TECHNICAL SPECIFICATION:

Specification No. TPD: 003-CABLESPEC

**SPECIFICATION FOR THE SUPPLY AND INSTALLATION OF
MEDIUM VOLTAGE AND LOW VOLTAGE ELECTRICAL
CABLES**

**SPECIFICATION FOR THE SUPPLY AND INSTALLATION OF MEDIUM VOLTAGE
AND LOW VOLTAGE ELECTRICAL CABLES**

REVISIONS		
REV	DATE	APPROVED
0	September 2022	
0	November 2025	

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APPENDICES

Appendix 1 - "Statement of Compliance"

1.1 SCOPE OF WORK

The scope of this specification covers the minimum requirements for the supply installation, testing and commissioning of medium and low voltage cables, instrumentation cables, cable racking, trenching, sleeves and earthing reticulation on Transnet sites on behalf of Transnet.

Contractors are required to familiarise themselves with all applicable Standards and Codes of Practice listed herein, and to ensure compliance in the execution of any work in terms of this document. Failure to comply may render the contractor liable for corrections at his own cost.

These Standards and Codes of Practice should be read in conjunction with all other Specifications and drawings as issued for a particular contract. Where discrepancies occur, these must be brought to the attention of Transnet in writing before commencement of work. In the event of any conflict between the contents of any documents forming part of a contract (as listed in the Master Index) and this document, the former shall prevail.

1.2 APPLICATION TO WORK ACTIVITIES

The Standards and Codes of Practice contained herein apply to all installations requiring Medium and Low voltage Electrical and Instrument Cabling, Racking, Trenching Sleeves and Earthing Reticulation and include amongst others the following standards:

- Supply of electrical and instrument cable trenches
- Supply, installation of electrical and instrument ladder racking reticulation
- Supply, installation of electrical and instrument dropper reticulation
- Supply, installation and termination of electrical and instrument cabling
- Cable Tagging and Core Identing standards for electrical and instrument cabling
- Supply, installation of instrument and electrical earthing

2. STANDARDS AND REFERENCES

2.1 The requirements of the materials, design, layout, fabrication, assembly, erection, examination, inspection and testing of equipment and facilities on site shall be in accordance with the relevant sections of codes: -

- | | | | |
|----|-----------------------|---|---|
| a) | SANS 10142-1 | - | Code of Practice for the Wiring of Premises |
| b) | SABS 763 | - | Hot dip (galvanising) Zinc Coating. |
| c) | SABS 1507 | - | Electric cables with extruded solid dielectric Insulation for fixed installation. |
| d) | SANS 1574 | | |
| e) | ASME/ANSI.B31.3 | - | Chemical Plant and Petroleum Refinery piping |
| f) | ASME/ANSI.B31.4 | - | Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia and Alcohols. |
| g) | SABS 089:Part II-1965 | - | The Petroleum Industry Part II: Electrical Code |

- h) SABS 089 - Part II - The Handling, Storage and Distribution of Petroleum Products (Electrical Code)
- i) SABS 0198 - "The Selection, Handling and Installation of Electric Power Cables of rating not exceeding 33KV"
- j) API 2003 - Protection against ignitions arising out of static, Lighting and stray currents.
- k) SABS 03 - The Protection of structures against lightning.
- l) SABS 086 - The Installation and Maintenance of Electrical Equipment used in explosive atmospheres. Refer to Section 2 for Hazardous area classification.
- m) IEC 79-14 - Electrical Installations in Hazardous Areas
- n) Government, local authorities or other statutory bodies' regulations, laws, requirements or customs which are more stringent than those specified in this project specification.

2.2 The following standard specifications are to be used for reference purposes and need to be noted by Contractors in order to signify familiarity and compliance with the requirements. It is expected of Contractors that they be familiar with the applicable clauses and that these will be adhered to in the execution of any work in terms of this specification. Contractors will be required to confirm that they are able to meet these requirements.

- a) SABS 0108 : 1995 The Classification of hazardous locations and the selection of electrical apparatus for use in such locations
- b) The Occupational Health & Safety (OHS) Act No. 85 of 1993.
- c) SABS 0314 Flameproof Enclosures for Electrical Apparatus
- d) SABS 0549 Intrinsically Safe Electrical Apparatus
- e) API Manual of Petroleum Measurement Standards Chapters 4 to 12
IP Chapter 10 and Papers 2 and 3
- f) SABS 969 Enclosures for electrical apparatus
- g) BS 5490 Classification of degrees of protection provided by enclosures
- h) Safety Regulations for Contractors
- i) Technical Instruction No. 16 - Contractors Work Permit Procedures.
- j) VDE Standards

2.3 Where no specific rules, regulations, codes or requirements are contained in this specification nor covered by the above mentioned codes, the contractor shall, in consultation with Transnet, adhere to internationally accepted modern design and engineering practices in the Electrical and Petrochemical Industry.

3.0 SERVICE CONDITIONS

3.1 The cable shall be designed and rated for continuous operation under the following conditions :-

3.1.1 Ambient/Environment Conditions :

3.1.1.1 Altitude : Sea level.

3.1.1.2 Ambient temperature : -5° C to +45° C (daily average +35° C).

3.1.1.3 Relative humidity : As high as 96%

3.1.1.4 Lightning conditions : Severe, with a maximum lightning ground flash density 11 flashes per km² per annum.

3.1.1.5 Exposure conditions : Salt laden, industrial atmosphere as well as hazardous gases and dust atmosphere.

3.1.1.6 Electrolytic corrosion conditions prevail in all the areas owing to the proximity of direct current traction system and cathodic protection schemes.

3.1.2 Electrical Conditions:

3.1.2.1 The system of supply will be three phase, 3 wire, 50 Hertz, 11KV alternating current for medium voltage and three-phase, 4 wire, 50 Hz 400 Volts alternating current for low voltage.

3.1.2.2 The voltage may vary within the range of 95% to 105% of the nominal and all cable shall be suitably rated.

4.0 RESPONSIBILITY FOR WORK, SAFETY

4.1 The Contractor shall be responsible for all aspects associated with the provision of the cables. This includes items such as supply of testing cable to test the cables prior to commissioning, provision of site office and storage facilities.

4.2 Occupational Health and Safety Act (Act No 85 of 1993) must be complied with in all respects during the execution of this contract. The onus shall be on the contractor to ensure that staff under his control adheres to the provisions of the act at all times.

5.0 ELECTRICAL CABLE SPECIFICATION

This part of the specification covers the general specification of electrical cables to be used on Transnet sites on behalf of Transnet Port Terminals.

5.1 TYPES OF CABLE

5.1.1 CROSS-LINKED POLYETHYLENE (XLPE)

5.1.1.1 Cross-linked Polyethylene (XPLE)-insulated cables shall be individually screened, 3 core, stranded copper conductor, type A, cable manufactured in accordance with SABS.1339. The cable is to be supplied with an overall graphite coating to the outer PVC sheath.

5.1.1.2 The cable shall have embossed on the outer P.V.C. sheath next to the **S.A.B.S.** mark the following letters:

T/G/B

where T = TRANSNET STANDARD G = GRAPHITE COATED B = BEDDING TEST

Only the above mentioned cable shall be accepted.

5.1.1.3 The cable shall be capable of withstanding continuous operational temperatures up to 90° C.

5.1.1.4 Completed cable runs are subjected to the following tests :-

- a. As laid down in S.A.B.S. 1339 (Appendix "E" paragraph E-1.4)
- b. Anti-electrolysis insulation, applied between armouring and earth, tested at 10kV D.C. for one minute. Bedding shall be tested at 4kV D. C. for one minute.

All the above tests shall be carried out in the presence of the Engineer

5.1.2 PAPER INSULATED

5.1.2.1 Fully impregnated hygroscopic paper insulated, Helically lapped, insulated, Three core, Stranded copper conductors, Outer layer numbered for core identification, Seamless pure lead sheath, Covered with bitumen impregnated paper, Single steel wire armoured, extruded plastic sheathed, Operational voltage 6.35 to 11kV.

5.1.2.2 The cable shall have embossed on the outer P.V.C. sheath next to the **S.A.B.S.** mark the following letters:

T/G/B

Where: T = TRANSNET STANDARD
G = GRAPHITE COATED
B = BEDDING TEST

Only the above mentioned cable shall be accepted.

5.1.2.3 The cable is to be supplied with the P.V.C. outer sheath impregnated with a high quality graphite powder coating.

- 5.1.2.4 Type general purpose copper woven taped screened (Table 19) cable manufactured in accordance with S.A.B.S. 97 is required.
- 5.1.2.5 The cable shall be capable of withstanding continuous operational temperatures up to 70 / 80° C.
- 5.1.2.6 Completed cable runs are subjected to the following tests
 - a. As laid down in S.A.B.S. 97
 - b. Anti-electrolysis insulation, applied between armouring and earth, tested at 10Kv D. C. for one minute. Bedding shall be tested at 4Kv D.C. for one minute.
All the above tests shall be carried out in the presence of the Engineer

5.1.3 LOW VOLTAGE PVC CABLE

- 5.1.3.1 Low voltage cables shall be PVC insulated cables with ECC, and shall comply with SABS.1507.
- 5.1.3.2 Earth continuity conductors shall be single core PVC insulated copper cables, and shall comply with SABS. 1507.
- 5.1.3.3 The cable shall be capable of withstanding continuous operational temperatures up to 70° C.
- 5.1.3.4 Electrical LV Power cabling installed in hazardous locations (flammable environment) running between Equipment located in the field, LV Panels or Motor Control Centre Panels, Valve Panels and Distribution Boards shall comprise of steel wire armoured, earth continuity conductor (ECC), PVC Insulated, four core cable, as follows:

Conductors.

Core Size : 4 core - Rated as per application (SABS 10142-1)
Stranded untinned copper, 7 strands minimum

PVC Insulated, Insulation Breakdown Voltage to withstand 2 kV 50Hz RMS for a 1 min period.

Insulation Colours: Colored RD-BL-YE/WT-BK (not numbered)

Lay Twist to be 40 – 60 mm (i.e. 16-25 twist per metre)

Inner Jacket

Extruded fire retardant black PVC with rip cord for jacket removal.
Minimum thickness 1.2mm

Outer Jacket

Overall weatherproof thermoplastic PVC jacket – fire retardant and UV resistant (Carbon black added).

Jacket thickness 1.5mm

Jacket to be totally bonded to a steel wire armoured sleeve.

Fire retardant, low halogen (20% Halogen, Blue Stripe) plastics to be used in non-ventilated areas. Fire retardant, high halogen (100% Halogen, Red Stripe) plastics may be used in ventilated areas. Fire retardant, no halogen (0% Halogen, White Stripe) plastics not required to be used.

- 5.1.3.5 Electrical Control cabling running between the Equipment located in the field, Control System Marshalling Cabinets, LV Panels and Incomer Breaker panels will comprise of steel wire armoured, PVC Insulated, multi-core cable, as follows :

Conductors.

Core Size : 7 core – 1.5 mm² (Valve Actuators)
12 core – 1.5 mm², 19 core – 1.5 mm² (Switchgear)

Stranded untinned copper, 7 strands minimum

PVC Insulated, Insulation Breakdown Voltage to withstand 2 kV 50Hz RMS for a 1 min
Insulation Colours: 7 core and less – colored BL-YE/WT-RD-GR-BK-BR-PR/OR
(Not numbered)

12 core and more – black, conductors to be numbered

Lay Twist to be 40 – 60 mm (i.e. 16-25 twist per metre)

Inner Jacket

Extruded fire retardant black PVC with ripcord for jacket removal.
Minimum thickness 1.2mm up to 7 core, 1.5mm for 12 and 19 core

Outer Jacket

Overall weatherproof thermoplastic PVC jacket – fire retardant and UV resistant.

Jacket thickness 1.5mm up to 7 core, 2.0mm for 12 and 19 core

Jacket to be totally bonded to a steel wire armoured sleeve.

Fire retardant, low halogen (20% Halogen, Blue Stripe) plastics to be used in non-ventilated areas. Fire retardant, high halogen (100% Halogen, Red Stripe) plastics may be used in ventilated areas. Fire retardant, no halogen (0% Halogen, White Stripe) plastics not required to be used.

- 5.1.3.6 Completed cable runs are subjected to the following tests as laid down in SANS 10142-1. Insulation resistance test between Phases, Phases and Neutral, Phases and ECC, Neutral and ECC.

5.1.4 INSTRUMENTATION CABLING

- 5.1.4.1 Instrument Cabling as defined within this and other Transnet Specifications includes the following types of cabling:
1. PVC SWA Multicore instrument cables running between Instrument Junction Boxes in the field and PLC Cabinets (IS and non-IS rated)
 2. PVC SWA Multicore instrument cables running between instruments in the field and PLC Cabinets (IS and non-IS rated)
 3. Dekabon armoured instrument cables running between Junction Boxes in the field and the instruments themselves (IS and non-IS rated)
- 5.1.4.2 All Instrumentation Cabling will comply in all respects to the specifications as contained in the Scope of Work attached to an Order. In the absence of cable specifications being detailed in the Scope of Work attached to an Order, the following cable specifications will apply.
- 5.1.4.3 Instrument cabling will be marshalled on Instrument racking and trenching as defined elsewhere within this specification.
- 5.1.4.4 Instrument multi-core cabling running between the Field Junction Boxes and the Control System Marshalling Cabinets will comprise of steel wire armoured, PVC Insulated, individual and overall screened multi-core cable. Note that Petronet has standardised on 1 pair, 2 pair, 8 pair and 16 pair cable – prior approval from Petronet will be required to deviate from these specifications.

Conductors

Core Size : 1.0 mm²

Stranded untinned copper, 7 strands minimum

PVC Insulated, Insulation Breakdown Voltage to withstand 2 kV 50Hz RMS for a 1 min.

Insulation Colours : Black and White

Multipair cores to be numbered (numeric on both conductors of the pairs)

Lay Twist to be 40 – 60 mm (i.e. 16-25 twist per metre)

Shield/Screen

Individual & overall screened – plasticised aluminium foil (100%) coverage

Stranded tinned copper drain wire 0.5 mm²

Inner Jacket

Extruded fire retardant black PVC with rip cord for jacket removal.

Minimum thickness 1.2mm up to 8 pair, 1.5 mm for 16 to 36 pair

Outer Jacket

Overall weatherproof thermoplastic PVC jacket – fire retardant and UV resistant (Carbon Black added).

Jacket thickness 1.5mm up to 8 pair, 2.0 mm for 16 to 36 pair.

Jacket to be totally bonded to a steel wire armoured sleeve.

Fire retardant, low halogen (20% Halogen, Blue Stripe) plastics to be used in non-ventilated areas. Fire retardant, high halogen (100% Halogen, Red Stripe) plastics may be used in ventilated areas. Fire retardant, no halogen (0% Halogen, White Stripe) plastics not required to be used.

IS Circuits: Jacket color light blue Non IS Circuits: Jacket color black.

5.1.4.5 Individual Instrument cabling running between the Field Junction Boxes and the individual field mounted Instruments will comprise of Dekabon armoured, PVC Insulated, individual and overall screened multi-core cable. Note that Petronet has standardised on 1, 2, 4 and Triad cable – prior approval from Petronet will be required to deviate from these specifications.

(Note that this specification only applies to cabling running on racks above the ground, all Instrument cables running in trenches will need to comply with the Instrument Multi-core Cable Specifications detailed above).

Conductors.

Core Size : 1.5 mm²

Stranded untinned copper, 7 strands minimum

PVC Insulated, Insulation Breakdown Voltage to withstand 2 kV 50Hz RMS for a 1 min

Insulation Colours : Black and White

Multipair cores to be numbered (alphanumeric on both conductors of the pairs)

Lay Twist to be 40 – 60 mm (i.e. 16-25 twist per metre)

Shield/Screen

Individual & overall screened – plasticised aluminium foil (100%) coverage

Stranded tinned copper drain wire 0.5 mm²

Inner Jacket

Extruded fire retardant black PVC with ripcord for jacket removal.

Minimum thickness 1.2mm

Outer Jacket

Overall weatherproof thermoplastic PVC jacket – fire retardant and UV resistant (Carbon black added).

Jacket thickness 1.5mm.

Jacket to be totally bonded to an inner waterproof aluminium sleeve, with a ripcord under the sleeve for jacket removal.

Fire retardant, low halogen (20% Halogen, Blue Stripe) plastics to be used in non-ventilated areas. Fire retardant, high halogen (100% Halogen, Red Stripe) plastics may be

used in ventilated areas. Fire retardant, no halogen (0% Halogen, White Stripe) plastics are not required to be used.

IS Circuits: Jacket color light blue Non IS Circuits: Jacket color black.

6.0 CABLE TERMINATIONS

6.1 Medium and Low Voltage cables shall be terminated to busbars and switchgear in the panels, distribution boards and kiosks using suitable cable lugs. Cable earth wires shall be brought into glands on gland plates. The insulation between cable armouring and cable earth wires shall be maintained at terminations. The separate earth conductor cable shall terminate to the main earth bar.

6.2 All materials necessary for installing all cable terminations shall be provided by the Contractor and the cost thereof shall be included in the tender price.

6.3 Glanding

6.3.1 All instrument and electrical cables will be glanded at both ends using the appropriate sized gland and will include associated adaptors, washers, ferrules, bands, etc. Provision for all glands, adaptors, washers, ferrules, bands etc. shall be included in the Tenderer's offers. All cable glands shall comply with the following specification, unless otherwise specified in the Scope of Work attached to an Order:

6.3.2 Dekabon Armoured Cabling (Instrumentation)
Increased Safety Ex"e" rated compression gland, IP68 rated, complete with UV resistant black shroud where required, in accordance with SABS 1031.

6.3.3 PVC SWA Cabling (Instrument & Electrical motors)
Increased Safety Ex"e" rated non-compression gland, IP68 rated, complete with SWA protection (CCG Corrosion Guard or similar), in accordance with SABS 1031.

6.3.4 PVC SWA Cabling (Ex"d" rated Valve Actuators)
Flameproof Ex"d" rated non-compression gland, IP68 rated, complete with SWA protection (CCG Corrosion Guard or similar), in accordance with SABS 808.

6.3.5 PVC SWA Cabling (Electrical and PLC Panels located within buildings rated as Safe Areas in terms of Hazardous Area Classifications SABS 0108)
Non-Flameproof rated, non-compression gland, IP68 rated, complete with UV resistant (black) shroud where required.

All glands will be waterproof and in the case of Hazardous Areas, correctly rated in terms of the Explosion Proof Classification of the equipment housings to which they are installed.

6.4 Termination

6.4.1 All cables will be terminated at field instrumentation, electrical equipment, field junction boxes, switchgear panels and control room marshalling cabinets according to

manufacturers specifications, instrument hook-up diagrams and control system specifications as provided/approved by Petronet.

6.4.1.1 Instrument Dekabon Cabling

- Outer Dekabon armouring shall be stripped back to the entry point into the associated termination/junction box. Protrusion of cable sheath/armouring into the termination/junction box (through the compression gland) shall be a minimum of 15mm and a maximum of 50mm.
- Cable pair inner aluminium foil shall be stripped back to the point at which the individual cores leave the PVC Trunking to be terminated onto the respective terminal rails. Ends of the inner foil shall be neatly taped/heat shrunk so as to prevent unravelling.
- Individual cable ends shall be sealed with the use of heat shrink tubing applied over the cable sheath/armouring at the point of entry into the termination/junction box/panel, in order to protect the cable and prevent the ingress of moisture.
- Both cable overall (drain wire) and individual screens shall be insulated with the use of appropriately sized green coloured sleeving, to prevent inadvertent contact with metallic surfaces.
- All individual cable cores (including spares) will be left long enough to accommodate 200mm slack, i.e. taking into account the routing via the trunking.
- Excess lengths of individual cable cores will be neatly folded and tied within the trunking provided. All spare cores shall be terminated into terminals so provided.
- Termination of individual cable cores in the termination strips will be such that all Control System related cabling will be terminated to one side of termination strips, whilst all field instrumentation/equipment cabling will be connected to the other side of termination strips.

In the case of Field Junction Boxes with dual terminal strips, multi-core cabling will be glanded in the centre of the gland plate and terminated into terminal rails provided, running from the centre PVC Trunking outwards. Individual Instrument cables will then be terminated into the terminal rails provided, running from the outermost PVC Trunking inwards.

In the case of Field Junction Boxes with single terminal strips, multi-core cabling will be glanded on the right side of the gland plate and terminated into terminal rails provided, running from the right hand side of the panel inwards. Individual Instrument cables will then be terminated into the terminal rails provided, running from the left hand side of the panel inwards.

- All cables connected to individual instruments/equipment will be provided with a single loop of minimum diameter of 150mm. All loops will be neatly strapped.

- All cores (including spares) will be terminated into allocated termination strips/rails in the respective Instrumentation, Termination and Field Junction Boxes

6.4.1.2 Instrument PVC SWA Multi-core Cabling

- Cable SWA armouring shall be stripped back to the entry point into the associated marshalling cabinet/junction box and shall be glanded in such a manner so as to ensure electrical continuity with the gland. When terminated in hazardous areas, cable armouring shall be bonded to the panel equi-potential bonding system via means of earthing rings provided as an integral part of the gland. Contact between the gland and the gland plate shall not be considered as sufficient for bonding purposes.
- Protrusion of cable inner PVC sheaths into the marshalling cabinet will be a minimum of 25mm and a maximum of 50mm.
- Cable inner aluminium foil shall be stripped back to the point at which the individual cores leave the PVC Trunking to be terminated onto the respective terminal rails. Ends of the inner foil shall be neatly taped/heat shrunk so as to prevent unravelling.
- Cable ends shall be sealed with the use of heat shrink tubing applied over the cable inner sheath at the point of entry into the termination/junction box/panel, in order to protect the cable and prevent the ingress of moisture.
- Both cable overall and individual screens shall be insulated with the use of appropriately sized green coloured sleeving, to prevent inadvertent contact.
- All individual cable cores (including spares) will be left long enough to accommodate 200mm slack, i.e. taking into account the routing via the trunking.
- Excess lengths of individual cable cores will be neatly folded and tied within the trunking provided. All spare cores shall be terminated into terminals so provided.
- Termination of individual cable cores in the termination strips will be such that all Control System related cabling will be terminated to one side of termination strips, whilst all field instrumentation/equipment cabling will be connected to the other side of termination strips.

In the case of Field Junction Boxes with dual terminal strips, multi-core cabling will be glanded in the centre of the gland plate and terminated into terminal rails provided, running from the centre PVC Trunking outwards. Individual Instrument cables will then be terminated into the terminal rails provided, running from the outermost PVC Trunking inwards.

In the case of Field Junction Boxes with single terminal strips, multi-core cabling will be glanded on the right side of the gland plate and terminated into terminal rails provided, running from the right hand side of the panel inwards. Individual Instrument cables will then be terminated into the terminal rails provided, running from the left hand side of the panel inwards.



- All cores (including spares) will be terminated into allocated termination strips/rails in the respective Instrumentation, Termination and Field Junction Boxes

6.4.1.3 Electrical Power and Control Cabling (Low Voltage)

- Cable SWA armouring shall be stripped back to the entry point into the associated equipment housing/termination box/panel and shall be glanded in such a manner so as to ensure electrical continuity with the gland. When terminated in hazardous areas, cable armouring shall be bonded to the panel equi-potential bonding system via means of earthing rings provided as an integral part of the gland. Contact between the gland and the gland plate shall not be considered as sufficient for bonding purposes.
- (Option 1) Cable inner PVC sheath shall be cut back at the point of entry into the equipment housing/termination box/panel, protrusion of the inner sheath into the associated switchgear cabinet/equipment housings shall be a minimum of 25mm and a maximum of 50mm. Heat shrink tubing shall be applied at the point of entry into the equipment housing/termination box/panel, in order to protect the cable and prevent the ingress of moisture.

(Option 2) Where cables are glanded into panels, cable inner PVC sheaths may be taken directly into trunking/marshalling arrangements, with the inner PVC sheaths cut back at point of termination. Note that in this instance, heat shrink need not be applied at the point of entry into the cabinet.
- All individual cable cores (including spares) will be left long enough to accommodate 200mm slack, i.e. taking into account the routing via the trunking.
- Excess lengths of individual cable cores will be neatly folded and tied within the trunking provided.
- Termination of individual cable cores in the termination strips will be such that all Starter related cabling will be terminated to one side of termination strips, whilst all field cabling will be connected to the other side of termination strips.
- All cables connected to individual instruments/equipment will be provided with a single loop of minimum diameter of 150mm. All loops will be neatly strapped.

6.5 Cable Core Lugging

All individual cable cores will be neatly terminated. Appropriately sized lugs will be attached to all core ends, using the appropriate crimping tool (not side cutters or ordinary pliers). The colouring of crimps will match the size of the associated cable core. All cable lugs utilised shall comply with the following specification, unless otherwise specified in the Scope of Work attached to an Order:

- Instrument Cables - bootlace ferrules

- Electrical Power Cables - spade lugs for compression terminals, ring lugs for screw terminals (pin lugs are not acceptable)
- Electrical Control Cables - spade lugs for compression terminals, ring lugs for screw terminals (pin lugs are not acceptable)

6.6 Cable Screening – Instrument Cabling

6.6.1 Individual Screens

6.6.1.1 All Individual Instrument Cable Pair Screens shall be terminated into terminals provided within the Instrument Termination Boxes as well as the Field Junction Boxes, and shall be grounded to a common insulated earth rail to be provided in each of the Control System Marshalling Cabinets, alongside the Termination Rails provided. Individual Screens shall be terminated in such a manner so as to be continuous from the Instrument/Instrument Termination Box to the Control System Marshalling Cabinets i.e. individual instrument cables as well as multi-pair cables.

6.6.1.2 Individual screen terminals shall be insulated in the Termination Boxes and Field Junction Boxes provided, thus ensuring that the individual cable pair screens are not grounded at instrument/equipment ends, i.e. to prevent common mode noise. Where Instrument Cables terminate directly into Instrument housings, individual screens shall be cut back and insulated within the Instrument housing using heat shrink sleeving, to prevent inadvertent contact with any conducting surfaces.

9.6.1.3 All individual screen earth rails in the Control System Marshalling Cabinets will be connected to the existing panel Instrument Earth bar via means of a 25mm insulated earth cable, which shall in turn be connected at two points via means of PVC Cu 70mm² insulated earth cables (Yellow/Green in colour), to the Instrument Earth bar located within the control room.

6.6.2 Overall Screens

6.6.2.1 All Instrument Cable Overall Screens/Drain wires shall be terminated to insulated earth bars provided within the Field Junction Boxes, and shall be earthed to a common electrical earth bar to be provided in each of the Control System Marshalling Cabinets. Overall Screens /Drain Wires shall be cut back and insulated within the Instrument Termination Boxes and Instrument housings (where applicable) to prevent inadvertent contact with the Termination Box housing, utilising heat shrink sleeving. Overall Screens shall be terminated in such a manner so as to be continuous from the Instrument Junction Box to the Control System Marshalling Cabinets.

6.6.2.2 The electrical earth bar shall be earthed to the Cabinet Frame, and connected at two points via means of PVC Cu 70mm² insulated earth cables (Yellow/Green in colour), to the Electrical Earth bar located within the control room.

6.7 Cable Screening – Electrical Cabling (Power & Control)

6.7.1 All electrical cable screens/drain wires (where applicable) will be grounded to a common electrical earth bar to be provided in each of the Control System Marshalling Cabinets/Switchgear Cubicles. The electrical earth bar shall be earthed to the Cabinet Frame,

and connected at two points via means of PVC Cu 70mm² insulated earth cables (Yellow/Green in colour), to the Electrical Earth bar located within the control and switchgear rooms.

7 ADDITIONAL REQUIREMENTS FOR EX IA/IB INSTALLATIONS

7.1 All I.S. (Ex ia/ib Intrinsically Safe) Installations shall be in strict compliance with IEC 79-14 Electrical Installations in Hazardous Areas, and in particular Chp 12 "Additional Requirements for type protection Intrinsic Safety", inclusive of the under mentioned items.

7.2 Clause 12.2.

In installations with Zone 1 and 2 classifications, IS apparatus and the intrinsically safe parts of associated apparatus shall comply to at least category "ib". Note that Petronet has standardised on category "ia" protection, and permission will need to be sought in writing for relaxation to "ib".

7.3 Cables – General

Where multi stranded cables are used in a hazardous area, the ends of the conductor shall be protected against separation of individual strands, by means of cable lugs.

Where cable screens are required, these shall be connected to earth at one point only, normally in the non-hazardous area. (Refer to Section 9.6 and 9.7 of this specification).

Cable armouring shall normally be bonded to the equi-potential bonding system via the cable entry devices (glands), at the end of each cable run. Where interposing Junction Boxes exist or other apparatus, the armouring shall be similarly bonded to the equi-potential bonding system at these points. In this regard and where earthing rings are provided as an integral part of the gland, use of these is recommended in serving this function. Contact between the gland and the gland plate shall not be considered as sufficient for bonding purposes.

Conductors of intrinsically safe circuits and non-intrinsically safe circuits shall not be carried in the same cable.

Conductors of intrinsically safe circuits and non-intrinsically safe circuits in the same bundle or duct shall be separated by an intermediate layer of insulated material or by an earthed metal partition. No segregation is required if metal sheaths or screens are used for intrinsically safe or non-intrinsically safe circuits. Note that Petronet has standardised on physical separation regardless of whether the cabling is screened or not, and permission will need to be sought in writing for relaxation.

7.4 Cables – Marking

Un-armoured Cables containing intrinsically safe circuits shall be marked. If outer sheaths are marked by color, the color used shall be light blue. Note that whilst armoured cabling

is not required to be marked in terms of IEC79-14, Petronet has standardised on the principle of marking all cable outer sheaths carrying intrinsically safe circuits by color (light blue), whether armoured or not, and that this will need to be complied with in all instances.

7.5 Cable Insulation Tests

All cables carrying intrinsically safe circuits shall be proven to be capable of withstanding an RMS AC test voltage of twice the normal voltage of the intrinsically safe circuit with a minimum of 500 V between the armouring and screens joined together and the individual conductors. Tests shall be conducted in accordance with manufacturers specifications. Where no such method is available, tests shall be carried out as follows:

- Voltage shall be an ac voltage of sinusoidal waveform at a frequency of between 48 and 62 Hertz
- Voltage shall be derived from a transformer of at least 500 VA output
- Voltage shall be increased steadily to the specified value in a period of not less than 10 seconds and maintained for a period of not less than 60 seconds.

7.6 Cable Termination

All terminals shall be reliably separated from non-intrinsically safe circuits (for example by a separating panel or gap of at least 50mm). Terminals of intrinsically safe circuits shall be marked as such. Petronet has standardised on marking by color - the specified color being light blue. All terminals, plugs and sockets shall satisfy the requirements of IEC79-11 Sections 6.3.1 and 6.3.2 respectively (6mm creepage and clearance rules 4mm to earth).

7.7 Zone 1 Installations - Surge Protection

All equipment installed in Zone 0 areas and exposed to hazardous potential differences (e.g. lightning surges), shall have a surge protection device installed between each non-earth bonded conductor/core and the local earthed structure as near as is practically possible. The surge protection device shall be capable of diverting a minimum peak discharge current of 10kA (8/20 microsecond impulse according to IEC60-1, 10 operations). The bonding connection between the protection device and the structure shall have a minimum cross sectional area equivalent to 4 mm² copper.

Note that Petronet has extended these requirements to include all analogue transmitters installed in the field, whether in hazardous areas or not, and will need to be complied with in all instances.

8. CABLE JOINTS

8.1 MEDIUM VOLTAGE CABLE JOINTS

- 8.1.1 The contractor shall give the Engineer advance notice of his intention to do jointing of medium voltage cables to enable arrangements to be made for measuring and inspection.

8.1.2 The complete cable installation, including all joints shall be fully insulated from earth throughout.

8.2 LOW VOLTAGE CABLE JOINTS

8.2.1 The low voltage cable through joints shall be of the epoxy resin filled type. The low voltage joints shall be constructed according to manufacturer's instructions.

9. CABLE ROUTES

9.1 All low voltage cables and associated earth continuity conductors shall be installed as shown in drawings PPD: BDD059C-E-01, sheet 1 of 3.

10. SURVEY OF ROUTE

10.1 The drawings showing the proposed cable route listed in the "Schedule of Drawings" shall not be taken to show the precise final cable route. The Contractor shall within 30 days after being awarded the Contract carry out a final route survey, which shall include digging test holes, and using the routes shown on the drawings as a general guide, to determine a suitable route.

10.2 The Contractor shall submit details of the cable routes selected in final survey to the Engineer for approval. No excavation of any section of the cable route shall commence until the Engineer has authorised the commencement of work on the section concerned.

10.2.1 After completion of all cable laying and jointing and before commissioning of any cable the Contractor shall carry out a final "as laid" survey of the cable routes and hand to the Engineer cable route plans. The cable route plans shall include the following information:

- (i) Overall length of each cable.
- (ii) Centre to centre distances between all joints and between final joints and terminations of each cable including auxiliary cables.
- (iii) Accurate indications of the position of each cable joint and cable marker preferably by triangulation, i.e. indicating two distances to each joint or marker from structures not likely to be moved such as permanent buildings, bridge piers, etc.
- (iv) Tables showing all information regarding each high-voltage cable necessary for cable fault location by the reflected pulse method.
- (v) Soil thermal resistivity and temperature values as determined on final survey shown on the plans at the positions where they were determined.

11. EXCAVATIONS



- 11.1 Excavations shall be carried out in strict compliance with the specification for works on, over, under or adjacent to a railway line No. E.7 (July 1998) (Part 1) that forms part of the tender documents.
- 11.2 The procedure and the order of doing the work shall be subject to the approval of the Engineer.
- 11.3 The Contractor shall, before trenching commences, familiarise himself with the route and conditions on site. The Contractor shall be advised of any known buried services such as cables, pipes, etc., in the vicinity of the cable route. However, the Contractor shall at all times exercise care to ensure that any uncharted services are not damaged.
- 11.4 Power driven mechanical excavators may be used for trenching operations provided that they are not used in close proximity to other cables, water mains, or any other plant liable to be damaged by the use of such plant. Their use along sections of the route shall in each case be subject to approval of the Engineer.
- 11.5 Trenches shall be as straight as possible and each trench shall be excavated to the dimensions indicated in this specification. The Contractor shall provide shuttering for use in places where danger exists should the sides of the trench collapse. The strength of such shuttering must be adequate especially where railway tracks in proximity are concerned and the shuttering must be braced across the trench. Provision of shuttering will be paid for per metre length of shuttered trench.
- 11.6 The bottom of each cable trench shall be as firm as conditions permit and be of smooth contour.
- 11.7 In sections where the soil or water level conditions indicate that the cable trench will endanger rail tracks or any nearby structures, the Contractor must restrict the length of continuous open trench to a distance to be indicated by the Engineer.
- 11.8 The Contractor shall take all reasonable steps to ascertain if the cables will be liable to be subjected to chemical or other damage or electrolysis action and shall submit his recommendations for approval, of any precautionary measures to be taken, in such instances.
- 11.9 The material excavated from each trench shall be placed adjacent to the trench in such a manner as to prevent nuisance or damage to adjacent ditches, railway lines, drains, gateways and other properties and shall be stacked so as to avoid undue interference with traffic. Where, owing to certain considerations, this is not permissible, the excavated materials shall be removed from the site and be returned for refilling the trench on completion of laying.
- 11.10 Surplus material shall be disposed of by the Contractor at his cost. Where the possibility exists that railway line ballast may be fouled by excavated material or material brought on site, the Contractor shall take precautions as directed by the Engineer.
- 11.11 The Contractor shall not trench beneath any railway line without departmental supervision. Should the contractor wish to carry out such work the Engineer must be



advised not less than 14 working days before hand to arrange for the necessary supervision. The cost of such supervision shall not be charged to the Contractor.

- 11.12 Prior to laying the cable, the trench shall be inspected thoroughly by the Engineer or his authorised representative to ensure that it is free from all objects likely to damage the cable either during or after cable laying operations. Cable laying shall not proceed unless the Engineer or his authorised representative is satisfied with the condition of the trench.
- 11.13 When trenching, the Contractor shall take all precautions necessary to prevent damage to any other cables, water mains, roads, pavements, drainage systems, building or any structure etc. Should any of the above be damaged by the Contractor's staff, it shall be reported immediately to the Engineer, who shall arrange for the necessary repairs. The Contractor is responsible for the cost of repairs.
- 11.14 Should it be necessary for any reason to remove accumulated water or other liquid from the trench, this shall be done by the Contractor at his expense and should be taken into account at the time of tendering. The Contractor is to provide all pumps and appliances required to carry out this operation. Water or any other liquid removed shall be disposed of without creating any nuisance or hazard.
- 14.15 Trenching procedure shall be programmed in advance with the Engineer and the programme approved by the Engineer shall not be departed from save with his consent.
- 11.16 Programming of trenching shall be on the basis of the Contractor giving the Engineer an assurance that any length of trench opened on a particular day will be back-filled and compacted to an adequately firm surface on the same day where possible. If it is anticipated that trenching will remain open for longer periods, the Contractor shall first obtain the approval of the Engineer. No new sections of trenching shall commence if previously uncompleted sections still exist. Under no circumstances may sections greater than 300 metres be opened.
- Where such approval is given, the onus shall be on the Contractor to safeguard the works to the satisfaction of the Engineer during the extended period such trenches remain open. Where cables have already been laid, but not covered, steps shall be taken by the Contractor to protect cables and the personnel around.
- 11.17 The near side of any cable trench shall preferably not be less than 2500mm from any adjacent railway line. Approval from the Engineer will be required if the above clearances cannot be achieved. The conditions of clause 13.1 shall apply.
- 11.18 The removal of obstructions along the cable routes shall be subject to the approval of the Engineer and shall be paid for at pre-agreed rates.
- 11.19 The area traversed by the cable routes has been used for many years. It is inevitable that there will be uncharted services. On encountering any such service the Contractor shall promptly advise the Engineer who shall direct what action shall be taken.
- 11.20 Transnet reserves the right to alter any cable route or portion thereof in advance of cable laying. Payment in respect of any additional or wasted work involved shall be at scheduled rates.

11.21 Any existing electrical cables obstructing the cable routes shall be removed or deviated as appropriate by the Contractor. The work shall be paid for at scheduled rates.

11.22 The bottom of the trench shall be filled with 200mm of suitable soil sifted through a 6mm mesh and levelled off. Only soil with a satisfactory thermal resistivity may be used for this purpose and ash which occurs on the route shall not be used. Where no suitable soil is available in proximity, imported fill shall be arranged. The manufacturer's assurance is required that the current rating of cables is not reduced by the ground conditions.

12.0 TRENCH/EXCAVATION SPECIFICATION

Separate Trenches shall be supplied to cater for the following cable types:

12.1 ELECTRICAL HV/MV TRENCHES

Trench Dimensions	:	1200 mm deep by 500 mm wide (two cables), add 300mm width for additional cables
River Sand Bedding	:	PVC Piping – 75 mm above pipe, 50mm under pipe
	:	Direct Burial – 100 mm
Identification	:	PVC or Concrete Interlocking Tiles at a depth of 350mm
Cable Markers	:	Concrete with engraved anodised aluminium ID plates cable Marker Colour – Brilliant Green
Cabling	:	Medium and High Voltage Power Cabling > 400 VAC
Separation	:	400 mm (LV cabling), 800mm (Instrument cabling)

12.2 ELECTRICAL LV TRENCHES

Trench Dimensions	:	800 mm deep by 300 mm wide
River Sand Bedding	:	PVC Piping – 75 mm above pipe, 50mm under pipe
	:	Direct Burial – 100 mm
Identification	:	Polythene Marker Tape (150mm wide, yellow and marked with the words "Electric Cable" at a depth of 350mm
Cable Markers	:	Concrete with engraved anodised aluminium ID plates. cable Marker Colour – Black
Cabling	:	Low Voltage Power Cabling 400 VAC/230 VAC (e.g. Actuators, Aux Motors, DB circuits)
	:	Control Cabling (e.g. MV Breaker Inter-tripping cables, Actuator control signals, Aux Motor local stop/start panels etc.)

Separation : 400 mm (HV/MV cabling), 800mm (Instrument cabling)

12.3 INSTRUMENT TRENCHES

Trench Dimensions : 500 mm deep by 300 mm wide

River Sand Bedding : PVC Piping – 75 mm above pipe, 50mm under pipe

: Direct Burial – 100 mm

Identification : PVC Tiles / Polythene Marker Tape (150mm wide, yellow and marked with the words “Electric Cable/Elektriese Kabel”) at a depth of 350mm

Cable Markers : Concrete with engraved anodised aluminium ID plates
cable Marker Colour – Light Blue

Cabling : Instrument Multi-core & Single Pair Cabling (IS and non IS)

Separation : 800mm (HV/MV/LV Electrical cabling)

13. CABLE LAYING

13.1 CABLES BURIED UNDERGROUND.

13.1.1 HV, MV, LV AND Instrument cables shall be spaced as indicated in Table 1 below. Pilot cables shall be laid beside the associated power cable. Cables crossing beneath railway tracks, roads, etc., shall be enclosed in 150mm diameter uPVC pipes. Where more than one length of pipe is required for a crossing, uPVC couplings with PVC glue, shall be used to prevent water from penetrating the joint. Cable pipes must maintain or exceed the specified cable spacing.

Table 1

CABLE	MINIMUM SPACING BETWEEN CABLES
MV To MV	300mm
MV To LV	400mm
LV TO LV	300mm
MV To instrumentation	800mm
LV To instrumentation	800mm

13.1.2 All pipes laid beneath the railway lines, roads, pavements shall be laid with their tops not less than 900mm below the formation level, and shall where possible extend at least 2000mm on either side of the centre of the outer most line. Where there is more than one



line crossed and in the case of roads and pavements at least 900mm on either side of the road and 1 or pavement. All pipes shall be graded for water drainage ; the required grade is 75mm in 30m.

- 13.1.3 All Low voltage cables shall be laid at a depth of 750mm. All cable depth measurements shall be made to the top of the cable when laid direct in the ground, otherwise to the top of the duct concerned.
- 13.1.4 Except where ducts, tunnels or pipes are provided and unless instructed to the contrary by the Engineer, the Contractor shall lay the cables direct in the ground.
- 13.15 Rollers may be used during the laying of cables, but they shall have no sharp projecting parts liable to damage the cables. They shall be carefully placed in the trench or duct in such a manner that they will not readily capsize during cable laying operations.
- 13.1.6 The Contractor shall ensure that all cable is laid in the same direction. No crossing of conductors inside through joints or end boxes will be permitted.
- 13.1.7 Where cables have to be drawn around corners, skid plates shall be used for this purpose and these plates shall be well lubricated. The skid plates shall be securely fixed between rollers and shall be constantly examined during the cable laying operations.
- 13.1.8 Cable shall be visually inspected for damage during and after laying.
- 13.1.9 Cable pulling and laying shall preferably be done manually whenever possible. Mechanical means such as winches and the like may only be used subject to the approval of the Engineer. No cable shall be subjected to a tension exceeding that stipulated by the cable manufacturer.
- 13.1.10 In the event of mechanical means of cable pulling being approved, the Contractor shall establish means of communication between the operator of the winch or other pulling device and the persons tending the drum from which the cable is being run off, to the satisfaction of the Engineer.
- 13.1.11 The contractor shall be wholly responsible for making his own arrangements for transporting all materials to and from and on the working sites.
- 13.1.12 At locations where cables run under concrete bridges, the cables shall be supported on suitable brackets secured on the side of concrete wall. These brackets shall be spaced a maximum of 500mm apart. Brackets and fixing material shall be of robust design and shall meet with Engineer's approval. Drawing of proposed ' bracket shall accompany tender. Brackets shall be galvanised in accordance with SABS 763, and thereafter painted to the satisfaction of the Engineer.

14.0 CABLES LAID IN DUCTS, CABLE TRAYS AND LADDERS

- 14.1.1 Cables in stalled in ducts shall be supported by cable ladder installed along the walls of the ducts or installed on the duct floor. If the cable ladder is installed on the duct floor, it shall be supported at +/- 50mm from the duct floor.

14.1.2 Cables installed in perforated cable trays and cable ladder shall be secured by means of heavy duty cable ties, cable clamps, etc.

14.1.3 Where medium and low voltage cables share the same wire-ways a reasonable space shall be left between the medium voltage and low voltage cables.

15.0 CABLE SLEEVING

15.1 All areas subject to vehicle traffic, rail crossings and paved areas shall be sleeved.

15.2 Sleeves shall be designed and installed so as to ensure 25 % spare capacity.

15.3 Sleeve Specifications

Material : PVC or PHD Polyethylene

Dimensions : 100 mm OD min

Standards : DIN EN50086-2, BS EN50086-2-4:1994

16.0 DRAW BOXES

16.1 Where cable sleeves are utilised and to facilitate the hauling of cables, brick draw boxes shall be provided at all trench junctions, complete with concrete slab, as detailed below:

Draw Box Dimensions (min) : Internal 450 mm square, 3 courses of stock brick deep.

Base & Top : Concrete 50mm thick

17. COVERING, BACKFILLING AND REINSTATEMENT

17.1 Filling in of trenches shall not be commenced until the Engineer or his authorised representative has inspected and approved the cables in situ in the section of trench concerned. Such inspection shall not be unreasonably delayed.

17.2 Where, in the opinion of the Engineer, the soil on site is unsuitable for riddling or backfilling, the Contractor shall arrange for the importation of approved material. A 75mm thick layer of soil sifted through a 6mm mesh shall be laid above the high-tension cables and consolidated by hand ramming only. The conditions of clause 13.20 apply in this case also.

17.3 All excavations made (whether for the purpose of cable laying, joint bays or trial holes) shall be back-filled in 150mm layers, the earth in each layer being well rammed and consolidated and sufficient allowance being made for settlement. The back-filling shall be completed to the satisfaction of the Engineer.

15.4 The refilled trench shall be maintained by the Contractor at his expense in a thoroughly safe condition for the duration of the contract. In the case of tarmac surfaces, until such time as this surface has been restored.



- 17.5 All backfilling of road crossings shall be mechanically rammed by means of approved type of mechanical power driven rammer.
- 17.6 The replacement of made up surfaces, such as roads, pavements, tarred aprons, verandas, floors, etc., necessitated by trenching or other works shall be arranged by the contractor at his cost. The price thereof shall be included in the tender price.
- 17.7 Concrete cable protection slabs to Drawing No. PPD-PA-10 shall be laid on top of the 75mm layer of soil referred to in clause 15.2 before the trenches are backfilled. Cable protection slabs shall be laid close butted, convex end to concave end, directly above each cable throughout the underground portion except where otherwise protected such as by pipes, etc. Three coloured slabs to drawing PPD-PA-9 shall be provided to give the indication of the route in the case of a change of direction. Only unbroken cable protection slabs, and those actually laid will be paid for.
- 17.8 When back filling of cable trench has reached a level, after consolidation, approximately 150mm below the normal level of the surface of the surrounding area the Contractor shall lay a continuous plastic cable warning tape directly above each cable for the full length of the cable trench before completing the backfilling.
- 17.9 Concrete cable markers to Drawing No. PPD-PA-12 shall be provided and installed by the Contractor at his cost. The price thereof shall be included in the tender price. Initial cable markers shall be installed as close as possible to cable terminations, thereafter at approximately 60m intervals and at cable joints, also on either side of crossings of oil pipelines and at ends of underground cable pipes.
- 17.10 Changes of direction and joints in cable runs shall be indicated by installing two markers at such positions in the manner shown on Drawing No. PPD-PA-12. The markers shall be coloured orange with oxide mixed into the concrete. Cable markers shall project approximately 25mm above normal ground level except where projecting cable markers could be a hazard to pedestrians such as in shunting yards, walkways, pavements, etc. In such cases the cable markers shall be flush with the surface.
- 17.11 If more than one cable is laid in one trench, only one row of cable markers shall be placed on the centre line of the trench to define the general route of the cables.

18. CABLE TESTING AND TEST DATA

- 18.1 All tests on completed cables shall be carried out in the presence of a representative of Transnet Projects. Not less than 14 working days notice of the Contractor's intention to carry out such tests shall be given to the Engineer.
- 18.2 On completion of the jointing and termination of cables, the 11kV cables are to be subjected to the test laid down in paragraph E-1.4 of Appendix E of S.A.B.S.1339 and the low voltage type cables to be tested for insulation and loop resistance.
- 18.3 The anti-electrolysis insulation of each 11kV cable run complete, shall withstand for 1 minute, a test voltage of 10kV D.C., applied from the cable armouring to earth. The bedding shall withstand a test voltage of 4kV D.C. between screen and armouring for 1 minute.

- 18.4 As a graphite coating is required to be applied to the PVC oversheath (in accordance with British Standard), a D.C. voltage test will be carried out on all cables after installation. The D.C. voltage test can only be carried out on the installed system if the joints are suitably insulated from earth, otherwise the D.C. voltage test should be carried out prior to jointing.
- 18.5 The contractor shall obtain written confirmation from the manufacture of all cables, joints and terminations -etc. that the test that Transnet Projects requires the contractor to carry out in terms of this specification meets with the manufacturers approval. Such confirmation must be obtained prior to any, tests commencing.
- 18.6 The electrical Contractor shall on completion of the tests submit three copies of all test results. The costs of all the tests mentioned above shall be borne by the Contractor.
- 18.7 In addition the cable manufacturer shall provide test sheets of each manufactured cable drum length together with the cable drum numbers which shows all the test results.
- 18.8 Transnet Projects reserves the right to carry out any further tests deemed necessary itself, using either the Contractor's instruments and cable, or its own, or both. The costs of such tests shall not be charged to the Contract.

18.9 **Cable Testing – Low Voltage Cables (< 1 kV)**

Each individual core of all cables (including spares) will be checked for continuity and insulation breakdown, in accordance with SABS 150 (PVC):

- Insulation Resistance shall be measured with a 1000V Megger and the readings tabulated and certified.
- Similarly, earth continuity resistance shall be measured and recorded.
- All cables will be checked for correct termination.

18.10 **Cable Testing – Medium Voltage Cables (< 22 kV)**

Each section of laid and jointed cable shall be tested, in accordance with SABS 97 (PILC/SWA):

- Insulation Resistance shall be measured with a 1000V Megger, followed by the relevant pressure test. Readings shall be tabulated and certified.
- AC test voltage must be applied to each phase in turn for one minute, or alternatively the DC test voltage for fifteen minutes. Leakage current shall be measured and recorded for each test.
- All cables will be checked for correct termination.

19. **MEASUREMENTS OF CABLES**

- 19.1 All measurements for payment purposes shall be made jointly by representatives of the Contractor and Transnet Projects and shall be agreed and approved by both parties.



- 19.2 Measurements of cable length shall be made from centre to centre of cable joints and to the cable ends and will exclude any wastage due to jointing and terminating.
- 19.3 Measurements of trench width and depth shall be made to the nearest 50mm and shall not take into account subsidence or unnecessarily large excavations. No allowance shall be made where trenches have to be widened at the bottom to accommodate cables, cable joints and protection slabs



Technical Specification
Specification No. TPD: 003-CABLESPEC

APPENDIX 1

STATEMENT OF COMPLIANCE (TO BE COMPLETED BY TENDERER)

This tender complies with specification TPD: 003-CABLESPEC in all respects.

SIGNATURE : _____ DATE : _____

This tender complies generally with specification TPD: 003-CABLESPEC but differs from it on the following points.

SIGNATURE : _____ DATE : _____



Transnet Port Terminals

TECHNICAL SPECIFICATION:

Specification No. TPD: 004-EARTHINGSPEC

**SPECIFICATION FOR EARTHING AND THE PROTECTION
OF BUILDINGS AND STRUCTURES AGAINST LIGHTNING**

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REVISIONS		
REV	DATE	APPROVED
	2025/06/11	
	2025/11/11	

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1.0 SCOPE

- 1.1 This specification covers Transnet Projects requirements with respect to the protection of buildings and structures against lightning and the requirements for air terminal systems, down conductors and earthing of installation of this specification
- 1.2 This specification applies to assessing, testing and upgrading of existing lightning protection systems and earthing on existing buildings and structures.

2.0 STANDARDS, SPECIFICATIONS AND DRAWINGS

- 2.1 The following publications (latest editions and amendments) are referred to herein.

South Africa Bureau of Standards (South African National Standards)

- | | | |
|----------------|---|--|
| SANS 10313 | - | The protection of structures against lightning. |
| SANS 62305 | - | Protection against lightning |
| SABS IEC 61643 | - | Surge protective devices connected to low voltage power distribution systems. |
| SANS IEC 60950 | - | Information technology equipment – safety. |
| SANS 10142 | - | Code of practice for the wiring of premises |
| BS 6651 | - | Code of practice for protection of structures against lightning. |
| BS 7430 | - | Code of Practice for Earthing. |
| SABS 064 | - | Code of Practice for the Preparation of Steel Surfaces for Coating. |
| SABS 086 | - | Installation and Maintenance of Electrical Equipment used in Explosive Atmospheres. |
| SANS 10108 | - | The Classification of Hazardous Locations and the Selection of Electrical Apparatus for use in such Locations. |
| SABS 0199 | - | The design and Installation of Earth Electrodes
SPECIFICATIONS |
| SABS 763 | - | Hot Dip Zinc (galvanised) Coatings |
| SABS 1091 | - | National Colour Standards for Paints. |
| SABS 1507 | - | Electric Cables with Extruded Solid Dielectric Installation for Fixed Installations |
| SABS IEC 742 | - | Isolating Transformers and Safety Isolating Transformers. |

OCCUPATIONAL HEALTH AND SAFETY ACT OF 1993 (ACT 85 OF 1993).

3.0 SERVICE CONDITIONS

3.1 The cable shall be designed and rated for continuous operation under the following conditions :-

3.1.1 Ambient/Environment Conditions :

- 3.1.1.1 Altitude : Sea level.
- 3.1.1.2 Ambient temperature : -5° C to +45° C (daily average +35° C).
- 3.1.1.3 Relative humidity : As high as 96%
- 3.1.1.4 Lightning conditions : Severe, with a maximum lightning ground flash density 11 flashes per km² per annum.
- 3.1.1.5 Exposure conditions : Salt laden, industrial atmosphere as well as hazardous gases and dust atmosphere.
- 3.1.1.6 Electrolytic corrosion conditions prevail in all the areas owing to the proximity of direct current traction system and cathodic protection schemes.

4.0 EQUIPMENT AND MATERIALS

- 4.1 Equipment and materials to be used, shall be of high quality, and shall comply with all relevant specifications, codes as mentioned in this specification as well as the Occupational Health and Safety Act of 1993(Act 85 of 1993).
- 4.2 Where equipment and material does not comply with the relevant specifications it shall be submitted to Transnet Project's Engineer for approval.
- 4.3 All materials used for the lightning protection system shall withstand the electric and electromagnetic effects of lightning current and predictable stresses without being damaged.
- 4.4 Materials and sizes shall be chosen bearing in mind the possibility of corrosion of either the lightning protection system or the structure to be protected.
- 4.5 Components of the lightning protection system may be manufactured from the materials listed in Table 8 of SANS 10313, provided they have sufficient electrical conductivity and corrosion resistance.

5.0 LIGHTNING PROTECTION REQUIREMENTS

- 5.1 The contractor shall carry out the installation in accordance with SANS 10313: Code of Practice for the protection of structures against lightning and the requirements of this specification.
- 5.2 Where the local supply authority requirements differ from those specified herein Transnet Projects's Electrical Engineer shall be approached for a decision.
- 5.3 All equipment and material shall comply with the relevant National or International standard

specification. Where equipment does not comply it shall be submitted to the Transnet Projects Electrical Engineer for approval.

- 5.4 The system of protection will be finials/air terminals, down conductors and earth spike or roof conductors, down conductors and earth spike.
- 5.5 The earth resistance for separate earth electrodes if down conductors are not connected to a ring earth shall be not exceed the following;
- Rt = 10 Ohm for category A structures
Rt = 15 Ohm for category B and C structures.

6.0 DESIGN OF LIGHTNING PROTECTION

The designer of lightning protection shall take into consideration the following principles and requirements during the design of the system.

6.1 GENERAL PRINCIPLES

- 6.1.1 Basic Principles of Lightning Protection:** the requirements of the basic principles of lightning protection as detailed in SABS 0313 shall be taken into consideration to ensure proper protection of structures against lightning.
- 6.1.2 Evaluation of Risk:** The risk of lightning stroke shall be evaluated as described in SANS 10313. For the purposes of tender, bidders to assume the most severe level of risk, class 1, for applications in hazardous locations and for structures with the most significant risk and potential damage from lightning strikes. For non-hazardous locations a risk requiring a class 2 LPL shall be assumed. Transnet requires that a lightning protection system is designed, supplied, and installed even if the risk evaluation results suggest that that is no risk. During execution, in a case where the risk evaluation shows that there is no significant risk, the risk results shall be submitted to Transnet's engineer and the Transnet's engineer will inform the contractor whether to omit the LPS application, continue with the LPS as per the bid, or to reduce the requirement to the lowest class of LPS.
- 6.1.3 Effective height of a structure (He):** The effective height of the highest point shall be determined by considering the average height of building, trees and structures and land profile of the surrounding area.
- 6.1.4 Ground flash density (Ng):** The ground flash density (Ng) for general buildings, structures and installations shall be estimated from the average ground flash density given in table 1 of SANS 10313 as a general guide. For important structures and installations, the value of the ground flash density shall be determined on the basis of at least 5 lightning years, or from existing records.
- 6.1.5 Number of flashes to structure per 100 year (Nt):** The number of flashes to structures per 100 year shall be determined taking into consideration type and the height of the structure as described in SANS 10313.

6.2 HAZARD CATEGORY

- 6.2.1 Buildings and structures where lightning protection system will be installed shall be categorised prior to the installation. Hazard categories are based on the nature of the building, its content and occupancy.
- 6.2.2 The Hazard categories are classified as follows in SABS 03 -1985 Code of practice for the protection of buildings structures against lightning.

Category A: High Hazard

Category A1: Structures and areas containing explosives of Category Z.

Category A2: Structures and areas classified as

- a) Division 0 areas in accordance with SABS089: Part II, or
- b) Class I, Division 0 locations in accordance with SABS 0108.

Category A3: Strategic control and communications installations such as airport towers

Category A4: Thatched-roof structures of historic values or that contain irreplaceable works of art or like values.

Category B: Medium Hazard

Category B1: Structures and areas containing explosives of Category X or Y.

Category B2: Structures and areas classified as

- a) Division 1 or 2 areas in accordance with SABS089, Part II, or
- b) Class I, Division 1 or 2 locations, or Class II, Division 1 location in accordance with SABS 0108.

Category B3: All structures not included in Category A and to which the public normally has access or which are of historic value.

Category B4: Large temporary structures used for exhibitions and entertainment.

Category B5: Thatched roof dwelling houses.

Category B6: Communications towers, water towers and reservoirs.

Category B7: Caravans and Yachts.

Category B8: Buildings and areas used for livestock, fuel or flammable material.

Category C: Low Hazard

Category C1: Small buildings that are infrequently occupied.

Category C2: Dwelling houses other than thatched-roof houses.

Category C3: Farm buildings, other than those included in category B8.

6.3 ZONES PROTECTION AND SHIELDING ANGLES

6.3.1 The zone of protection shall be the area covered by either one of the following types of protection:

- a) Single Vertical air terminal
- b) Single horizontal air terminals
- c) Area between two or more air terminals
- d) Area between roof conductors.

6.3.2 The shielding angles ρ and β are given in table 3 of SABS03-1985, Code of practice for the protection of buildings and structures against lightning.

- 6.3.3 The zone protection for Shielding Angles on Steep Slopes and High Ridges is not considered effective beyond a horizontal distance from the nearest air terminal of greater than $2H_e$, where H_e is the effective height of the part of the air terminal above its immediate surroundings.
- 6.3.4 In roof areas away from the edges of tall structures (generally of $H_e > 50\text{m}$), shielding angles given in table 3, SABS 0313 can be used appropriate to hazard category of the roof area so protected and the effective height H_e of the air terminal above the roof area.

6.4 SELECTION OF AIR TERMINAL

- 6.4.1 Mast Protection:** An air terminal consisting of one or more masts that cover the structure or area to be protected with the appropriate shielding angle will, with the possible exception of a few weak lightning strokes, successfully intercept lightning strokes.
- 6.4.2 Air Terminals as Part of the Structure:** An air terminal as part of the structure may be one or more of the following:
- A continuous metal roof.
 - A metal roof structure supporting a metal roof
 - The metal reinforcement in the roof of a reinforced concrete structure with peripheral conductors and finials where necessary.
 - Roof conductors and finials, where necessary, on a non-conducting roof.
 - Finials in chimney, gable ends, parapet walls, etc.
- 6.4.3 Air Terminal Systems For Category A Hazards:** The protection is based on the principle that a primary air terminal system must be provided for the interception of major lightning strokes with, if necessary a secondary air terminal system for the interception of those weak lightning strokes that might penetrate the protection of the primary air terminal system. The secondary air terminal system shall not be intended to carry currents of major lightning strokes.

One of the following lightning protection systems shall be used as detailed in SANS 10313.

- Mast protection used as a primary air terminal
- Metal roof used as primary air terminal system
- Reinforced concrete structure used as primary air terminal system.

6.5 MASTS AND CATENARY CONDUCTORS OVER THE STRUCTURE TO BE PROTECTED

6.5.1 GENERAL

- 6.5.1.1 A lightning protection system consisting of free standing masts separate from the structure provides the highest degree of protection, subject to the correct positioning of the mast and to the correct choice of shielding angle.
- 6.5.1.2 The number and height of masts (and, where necessary, the provision of the catenary conductors between the masts) shall be based on cost, aesthetics, shielding angles and mechanical consideration

6.5.2 CLEARENCE FROM STRUCTURES



6.5.2.1 A safe clearance distance shall be kept between the mast and the catenary conductor strung between the masts and the structure to be protected by the mast or the catenary conductor. The clearance distance depends to various factors detailed in SANS 10313.

6.5.2.2 Where a common earth electrode is provided for mast and structures in close proximity, the following clearance distance “d” shall be maintained with a minimum of 100 m.

- a) Between the mast and any point of structure: $d \geq 0,06.h$ m.
- b) Between the catenary conductor and any part of the upper surface of the structure: $d \geq 0,1.(L/2)$ m for Category A hazard, and $d \geq 0,06.(L/2)$ m for Category B and C hazards.
- c) Between a network of conductors and any part of the upper surface of the structure: $d \geq 0,1.(D + (L - D)/N)$ m for Category A hazard, and $d \geq 0,06.(D + (L - D) / n)$ m for Category B and C hazards.

Where $L =$ length of path measured from the base of one mast along the catenary conductor to the base of the other mast between which the catenary conductor is suspended, m.
 $D =$ spacing between the mesh of the network measured along the catenary conductor, m
 $h =$ height of structure, m
 $n =$ number of cross bonds between two catenary conductors.

6.5.2.3 Where the earth electrode of a mast is separate from the metal water main, other services or the earth electrode of a structure, the following clearance distance “d” shall be maintained with a minimum of 1.00 m:

- a) Between the mast and any point of the structure: $d \geq 0,06.h + 0,1. R_s$ m.
- b) Between a horizontal catenary conductor and any part of the roof of the structure: $d \geq 0,06.(L/2) + 0,1. R_s$ m.

Where $R_s =$ numerical value of the earth electrode resistance of the mast or, where masts are connected together by a catenary conductor, of the mast thus connected together, measured in ohms.

6.5.2.4 The minimum clearance distance “d” where the structure has no earth electrode and has limited water or electricity supply, shall be maintained within the following minimum clearance distances:

- a) $d \geq 1,00$ m between the mast or catenary conductor and any part of the structure.
- b) $D \geq 0,1 R_s$ m between the mast and any water pipe or electric cable, whether buried or above ground unless the mast electrode is bonded to the metal pipe of the underground water main. If R_s is not known, the clearance distance D must be at least 3m.

6.5.3 MAST PROTECTION IN THATCHED ROOFS

6.5.3.1 Thatched roofs shall be protected by one or more free-standing masts only. The zone of protection of the masts must include gable ends, chimneys, antennas, vent pipes and any other metal objects.

6.5.3.2 Telephone wires, overhead services connections to the electricity supply, or other overhead metal wires or pipes, shall not enter the structure through or close to the thatch.

6.5.3.3 On remote chimneys or gable ends close to imaginary surface of the protection zone, install a finial and down conductor well away from the thatch.

6.5.3.4 Metal wires and metal-coated insulating sheets used in the construction of the thatched roof shall be bonded together and to the earthed metal water main or electrode of the structure.



6.5.3.4 Where metals used in the construction of the roof are not bonded and earthed, a minimum clearance distance c of 1m between metals of the roof and water pipes, vent pipes, tanks, gas pipes, antennas, telephone and bell wires, bugler alarms and electrical wiring and conduits shall be maintained.

7.0 INSTALLATION

7.1 AIR TERMINALS ON THE STRUCTURE TO BE PROTECTED.

7.1.1 The purpose of an air terminal on a structure to be protected shall be to intercept lightning strokes at preferential points of an air terminal, thereby:

- a) Minimizing penetration of a lightning discharge current which could have followed a random path in the roof structure with possibility of a resultant fire.
- b) Preventing the loosening of masonry or the cracking of precast panels or reinforced concrete.

7.1.2 The selection of the air terminal system and the the position of down conductors shall be so selected such that at any likely point of incidence of lightning stroke, there are at least two parallel paths for the current to floe to earth.

7.1.3 Parallel routes shall not be necessary in the following cases.

- a) An air terminal on a small structure having only one prominent point of incident.
- b) Dead-ended conductors, i.e those conductors of the air terminal for which it is not feasible to provide a connection to a down conductor.

7.1.4 Where a peripheral roof conductor is required for the protection of the outer side edge of a structure, the conductor shall be installed as close to the edge as is practicable (preferable not more than 100mm from the outer edge)

7.1.5 Where buttresses or parapet walls are not already equipped with an air terminal in the form of continuous metal cladding or similar metalwork and peripheral conductors are to be provided at an effective height H_e of 15 m or more, finials shall be added on all exposed outer corners and at intervals not exceeding 30 m between outer corners. The finials shall be placed as close as possible to the outer edge, and so position the down conductors such that their connection to the peripheral conductor is close to the finial.

7.1.6 Concrete masonry chimneys or gables ends that are not protected with the appropriate shielding angle of another structure shall be protected by means of a finial or metal cap. Where the chimney or gable end is of masonry, a peripheral conductor along the gable or around the chimney shall be used instead.

7.1.7 Where it is not feasible to provide a down conductor at one end of an air terminal or a connection to another part of the lightning protection system, a dead ended conductor shall be used provided it is not longer than 10 m an generally flows a horizontal or downward course from the free end to end connected to the remaining part of the lightning protection system.

7.1.8 Where a dead-ended conductor partly flows an upwards course, the dead-ended conductor shall be not longer than 7.5 m. If the top of the protected part is considerably lower than the ridge conductor to which



the dead-ended conductor is connected, a finial shall not be used at the free end, unless it is required for the enhancement of the protection of the surrounding area, in which case an additional down conductor at the free end is recommended.

- 7.1.9 Metal gutters shall be bonded along the outside perimeter of the roof to the nearest down conductor, or to the metal of the roof, where applicable.

7.2 METAL ROOFS AND NON-METAL ROOFS SUPPORTED BY METAL ROOF STRUCTURES

- 7.2.1 Structures having roofs covered with electrically continuous metal sheets do not require air terminals, but shall be earthed by down conductors.
- 7.2.2 Sheet metal separated from each other by insulating strips or by epoxy or plastic coatings, may be regarded as providing continuous metal roof. However where sparking between such roofing is considered undesirable because of magnetic interference, all sheets adjacent to the ridge conductor or peripheral conductor shall be bonded.
- 7.2.3 A non-metal roof consisting of non-combustible roofing material held by metal fasteners to a roof supporting structure of metal construction may be considered to be a metal if the metal structure is earthed by down conductors, or supported by earthed metal columns, and spacing between roof beams does not exceed 15m for Category B and C hazards.

7.3 REINFORCED CONCRETE STRUCTURES

- 7.3.1 Reinforced steel shall not be used as parallel paths to enable lightning discharge current to flow safely to general mass of the earth.
- 7.3.2 Air terminals or finials and where necessary peripheral conductors shall be installed, taking into consideration the likely points of incidence of lightning and the path of the current through internal down conductors.
- 7.3.3 Where the outer support columns of the structure may be regarded as continuous from roof to basement, the peripheral and air terminal conductors shall be bonded to the internal or external down conductors.
- 7.3.4 Peripheral conductors and finials shall be used for medium height structures with reinforced concrete. Where the peripheral conductor is on a parapet wall that surrounds a metal roof or the air terminals of other structures, the other air terminal shall be connected to the peripheral conductor, preferably close to a down conductor. The peripheral conductor and other air terminal shall be connected to internal or external down conductor.
- 7.3.5 If the upper edge of the structure with chimneys and cooling towers and of medium height is not metal clad, horizontal conductors around the upper circumference of the structure, equipped with finials at intervals of not more than 15 m, with a minimum of two shall be installed.
- 7.3.6 On tall reinforced concrete structures, one of the following shall be installed in order to increase the protective efficiency, depending on the risk and the degree of protection required, height and slenderness of the structure:
- a) At intervals of not more than 10 m, install oblique finials along the upper perimeter, pointing upwards and outwards such that the tip of each finial points outwards at an angle of 30° to the vertical through the outer edge of the structure, and is at least 400mm above the structure, each

- finial being connected to a peripheral conductor.
- b) A horizontal conductor that follows the contour of the structure and that is so raised on oblique struts of length at least 500 mm that the conductor is displaced outwards at an angle of 30° to the vertical through the outer edge of the structure.
 - c) Oblique finials spaced as in (a) above, positioned on a horizontal conductor arranged as in (b) above and in line with the oblique struts, each finial pointing upwards and outwards at an angle of 30° to the vertical through the outer edge of the structure, and of length such that the tip of the finial is at least 800 mm above the outer edge of the structure.

Where the structure is slender, an air terminal as in (b) or (c) above is to be preferred to that in (a)

The air terminal shall be bonded to the internal down conductor at intervals not exceeding 10 m, or where the circumference exceeds 60 m, at appropriate intervals not exceeding 30m with a minimum of six bonds.

7.4 FINIALS AND ROOF CONDUCTORS

- 7.4.1 Roof conductors and finials shall be installed along the ridges of the roof and on other projections, in accordance to SANS10313 – code of practice for the protection of structures against lightning.
- 7.4.2 Protruding metal objects shall be bonded in a horizontal or in a downwards direction to the nearest roof or down conductor where the distance between the metal object and the conductor is less than 7.5m otherwise provide a separate down conductor. In all cases where the pitch of the roof is less than 30° , metal gutters and roof conductors shall be bonded or eaves conductors shall be provided.
- 7.4.3 In the case of large roofs of non-conducting material, additional conductors shall be installed across the surface of the roof, perpendicular to the long side of the roof and at extremely equal spaces not exceeding 15m. If the width of the roof exceeds 15m install conductors to form a grid at approximately equal spacing not exceeding 15m in either direction.
- 7.4.4 Roof conductors, finials and roof conductor grids shall be connected to the closest down conductor.
- 7.4.5 All roof conductors shall be manufactured from SABS approved single-core bare aluminium conductor with a minimum cross sectional area of 25mm².

7.5 DOWN CONDUCTORS

- 7.5.1 Down conductors shall be installed close to the point of the air terminal that are most likely to be struck by lightning and preferably run them vertically along the most direct route to the earth electrode.
- 7.5.2 At least two down conductors shall be provided in a building, such that in plan view no point of a structure is more than 15m from the nearest down conductor, except for masts and small structures having only one prominent point of incident, such as rondavels, these need only one down conductor.
- 7.5.3 Each down conductor shall be supplied with a separate earth electrode. This will reduce the current flow per down conductor, resulting in a lower voltage drop across the down conductor caused by the surge impedance of the conductor.
- 7.5.4 Down conductors shall not be placed close to doorways or entrances to buildings. Maintain a minimum clearance distance of the order of 1 m from the door and window frames, balustrades and other large metal objects.

- 7.5.5 Where down conductors deviate from a vertical route due to sharp bends and loops required to carry a conductor over eaves and parapet walls, shall be permitted, provided that all requirements stated in SANS 10313, clause 6.1.4 are met.
- 7.5.6 Steel columns and internal metal storm water drain-pipes shall be used as down conductors only if they are joined by screwing, bolting or welding.
- 7.5.7 External metal stair cases, fire escapes or other large frames shall be used as down conductors if they are electrically continuous over their full height. If not electrically continuous they shall be bonded to the lightning protection system at the top or at the bottom of the framework.
- 7.5.8 In the case of structures of Hazard Category A, Test joints shall be installed in down conductors at convenient heights above finished ground level.
- 7.5.9 Internal reinforcing steel of vertical concrete column, particularly those on the outer corners can be used as down conductors, provided that the reinforcement is electrically continuous.
- 7.5.10 Vertically discontinuous reinforcement shall be bonded between the reinforcement of each section to provide a continuous path to ground or an external down conductor shall be installed.
- 7.5.11 Large external metal frames, balconies and metal cladding on the top floors of tail structures (typically 30 floors or more) that may be exposed to direct lightning strokes must be bonded to the reinforcement of the structure or to a down conductor that is connected to the reinforcement of the roof.

8.0 STATUTORY REQUIREMENTS

- 8.1 The Contractor shall ensure that the installation satisfies the requirements of all relevant South African Statutory Regulations
- 8.2 Where applicable, equipment items shall carry the SABS mark to demonstrate compliance with the regulations.

9.0 RESPONSIBILITY FOR WORK

- 9.1 The tenderer shall be responsible for the complete installation of the lightning protection system including testing, earthing conductors, surge protection devices, spikes etc. as required for various buildings and structures. These installations shall include the review and the upgrading of the existing lightning protection systems. Due considerations shall be taken of the effects of lightning covered herein below in clause 8, in providing the lightning protection system.
- 9.2 The tenderer shall undertake to repair all faults due to bad workmanship and/or the use of faulty materials and to replace all defective materials within six months after the installation date.
- 9.3 The tenderer shall rectify all the defects to the satisfaction of Transnet Projects, that may become apparent during the guarantee period.
- 9.4 The tenderer may be required to carry out builders work such as cutting of concrete columns and coring of holes for testing of the continuity of the existing steelwork or cabling. Good contact between reinforcing bars should be ensured.

9.0 APPLICABLE INFORMATION

- 10.1 **Electrical effect** – The current discharged through the earth electrode resistance produces a resistive volt drop which may raise the potential of the system to a high value relative to true earth.
- 10.2 **Side-flashing** – The point of strike may be raised to a high potential, and there is a risk of flashover from the protection system to any metal or in the structure.
- 10.3 **Thermal effect** – The thermal effect of a lightning discharge is confined to the temperature rise of the conductor through which the current passes.
- 10.4 **Mechanical effect** – When a high current is discharged along parallel conductors in close proximity or along a single conductor with sharp bends, a different mechanical effect is exerted by a lightning flash. This is due to a sudden rise of 30 000K in air temperature and the resulting explosive expansion of the adjacent air in the channel along which the charge is propagated.

11.0 PROTECTION AGAINST CORROSION

- 11.1 The tenderer shall ensure that atmospheric, chemical and or electrolytic corrosion of copper and other metals is prevented from occurring when used for the lightning protection system.
- 11.2 The contact surfaces of dissimilar metals shall be kept completely dry and protected against ingress of moisture to prevent the acceleration of electrolytic corrosion.
- 11.3 Although copper is highly resistant to many types of chemical attack, lead coating shall be recommended wherever subjected to severe corrosion due to presence of sulphur compounds.
- 11.4 Stainless steel material of similar grading shall not be used unless prior approval is obtained.

12.0 EARTHING CODES OF PRACTICE

This part of specification details standards and codes of practice to be adhered to in the supply, installation and termination of earthing systems on all Transnet Sites.

12.1 National Standards

- 12.1.1 The requirements of the materials, design, layout, fabrication, assembly, erection, examination, inspection and testing of an earthing system on site shall be in accordance with the relevant sections of codes: -

- SABS 089 Part 2 1965 Electrical Code for Petroleum Industry
- SABS 0121 1977 Cathodic Protection of Buried and Submerged Structures
- SABS 0123 1976 The Control of Undesirable Static Electricity
- SABS 0198 Part 12 1988 Installation of Earthing System
- SABS 0199 1985 The Design and Installation of and Earth Electrode
- SABS 0200 1985 Neutral Earthing in Medium Voltage Industrial Power Systems

- SABS 0292 1999 Earthing of Low Voltage (LV) distribution systems
- SANS 10313 Latest ammed Protection of Structures against Lightning
- SABS 1063 1998 Earth Rods and Couplers
- SABS IEC 61000-5-2 1997 Electromagnetic Compatibility (EMC)
Part 5: Installation and mitigation guidelines
Section 2: Earthing and Cabling
- SABS IEC TS 61312-2 1999 Protection against Lightning Electromagnetic
Impulse (LEMP) Part 2: Shielding of structures, bonding
inside structures and earthing
- SABS IEC 61024-1 1990 Protection of Structures against Lightning
Part 1: General principles
- SABS IEC 61024-1-1 1993 Protection of Structures against Lightning
Part 1: General principles
Section 1: Guide A – Selection of protection levels for
lightning protection systems
- SABS IEC 61024-1-2 1998 Protection of Structures against Lightning
Part 1-2: General Principles
Guide B – Design, Installation, maintenance and inspection
of lightning protection systems
- SABS IEC 61312-1 1995 Protection against Lightning Electromagnetic
Impulse Part 1: General principles
- SABS IEC 61312-4 1998 Protection against Lightning Electromagnetic
Impulse Part 4: Protection of Equipment in existing
structures
- SABS IEC 61643-1 1998 Surge Protective Devices Connected to Low
Voltage Power Distribution Systems
Part 1: Performance requirements and testing methods
- SABS IEC TS 61312-2 1999 Protection against Lightning Electromagnetic
Impulse (LEMP) Part 2: Shielding of structures, bonding
inside structures and earthing

12.1.2 Statutory Requirements

- a) The Contractor shall ensure that the installation satisfies the requirements of all relevant South African Statutory Regulations
- b) Where applicable, equipment items shall carry the SABS mark to demonstrate compliance with the regulations.

12.2 Technical Requirements

12.2.1 General

- a) A common integrated station earthing system shall be provided for electronic and electrical systems equipment, static and lightning protection in accordance with the requirements of this document.
- b) A soil resistivity survey shall be carried out by a specialist earthing consultant/contractor. The consultant/contractor shall prepare a detailed report on the conditions identified and provide the survey data recordings together with proposals, for a basis of the earthing system design. The survey shall be witnessed by the Transnet's Engineer.
- c) Major electrical equipment such as switchgear, transformers, lighting boards, floodlight towers on poles, control panels etc. and associated metallic support frameworks, shall be connected to the station safety earth via Electrical Earth bars located nearby.

Use of embedded conductors within a power cable (spare core earth) may be utilised as the primary equipotential bonding system provided the following conditions are met: (SABS 086-1:2001)

- The embedded conductor has a cross-sectional area equal to those of the live and neutral conductors or equal to the values in Table 1 of SABS 0142)

In addition, a second visual earth connection shall be provided to each item of electrical equipment, to prevent the potential to earth of such equipment rising above spark potential. (SABS 089-2:2000)

- d) The neutrals of generators and transformers shall be connected to the main earth grid either directly or via an earthing resistor, as required. Where neutrals of transformers are connected directly to earth, this shall be done via means of connections to both an individual earth rod located nearby as well as to the station earth mat by means of Electrical Earth bar located within the Switchgear Room.
- e) Frames of motors shall be connected to the earthing system in accordance with the following table:

Motors kW Rating	Minimum Earth Conductor Size
Up to 30	16 mm ²
37 – 132	50 mm ²
150 – 175	70mm ²

Note:

In order to minimize the number of different sizes of earth conductor, the above three sizes only shall be used throughout, unless specifically stated otherwise.

- f) Cables supplying lighting fixtures shall be 3 core for single-phase supplies and 5 core for 3 phase supplies, of which one core shall be used as the earth conductor.

- g) Plant Infrastructure such as manifold piping, tanks and metallic support frameworks, shall be connected to the station safety earth, either directly or by means of Electrical earth bars located nearby.
- h) Flanged joints in metallic pipelines shall be considered inherently continuous provided the surfaces of one of the bolts are cleaned and identified for earthing. Flanges of metallic pipelines that have insulated linings for purposes other than cathodic protection shall be bonded to ensure electrical continuity.

Pipelines shall only be connected to the earthing system where they enter and leave the battery limits.

- i) Storage tanks that are not cathodically protected shall be earthed through at least two separate connections to the tank. Tanks shall be earthed in accordance with the relevant SABS code.

Electrically continuous structural steel columns may be used as down conductors by means of which elevated tanks, vessels, etc. shall be deemed to be connected to the earthing system.

All tank covers, gauge floats and stirrers etc. as well as all pipes entering the tanks shall be earthed.

The steel roof shall be in a direct electrical contact with, or bonded to the tank shell.

Earthed grids, gauges, gratings and the like placed in or across the inlets of tanks are not to be used as a means of static discharge. Individual bonding shall be made to the earthing system.

- j) Cable trays and cable racks shall have continuous earth continuity. This shall be ensured by installing 10mm² earth straps across the racking fishplates (joints). Cable Trays shall be connected to the earthing system in two places - where they enter and leave the battery limits.
- k) Earthing connections to all equipment and process plant shall comprise of welded earth bosses in compliance with SABS 089 Part II:1965 regulation 5.1.4K with properly provided terminations i.e. 10mm diameter earth studs. Anchor bolts shall not be used.

Earth connections to all equipment shall be effectively bolted, using crimped lugs.

All cable connections shall be fitted with a "star" or serrated washer in addition to the backnut, to ensure good earth contact.

- l) All earthing connections between the station earth system and respective earth bars/lightning protection systems shall where possible be made above ground, by means of bolts, crimped lugs and PVC taped.

All cable connections shall be fitted with a "star" or serrated washer in addition to the backnut, to ensure good earth contact.

Earth connection points shall be clearly labelled.

In cases where earth connection points are required to be made underground (e.g. to earth



rods), inspection wells shall be provided comprising of pre-cast concrete/PVC surrounds complete with covers, to facilitate periodic inspection.

- m) Earthing conductors rising through paving or other concrete work shall be run in suitable protective sleeves which shall project above finished level.
- n) Earthing and bonding conductors shall be sized and installed in compliance with regulations detailed in the current SAIEE Standard Regulations for the Wiring of Premises and in SABS 03 as applicable.
- o) Extendable earthing rods shall be manufactured from stainless / copper clad / galvanized steel (dependant on soil acidity and chlorides and existence of cathodic protection systems) 16mm diameter, 1200 mm long sections, and shall have molecular bond between the two metals to prevent moisture ingress. Where it is necessary to join earth rods together, a non-ferrous corrosion resistant coupling device shall be used which shall prevent the ingress of moisture into the joint.
- p) Lightning and static earthing protection shall be provided for all tall steel, masonry and concrete structures, towers, vessels, tanks etc, as well as all buildings used to house sensitive electrical/electronic equipment. Lightning protection systems shall be connected both to individual earth rods as well as bonded to the station earth mat. Where possible, the mesh method (as defined in SANS 10313) should be utilised in the protection of buildings against lightning strikes i.e. the use of masts and catenary conductors are to be avoided.

Tall steel structures such as towers or structure columns, provided they are electrical continuous, shall be considered inherently protected against lightning by their connection to the earth.

- q) **The resistance of the common earthing system to the general mass of earth shall not exceed 1 Ohm.**
- r) Where a separate system is installed for other than electrical equipment in remote locations, e.g. storage tanks; its resistance to the general mass of earth shall not exceed 7 Ohms. (Note: This applies only for Lightning Protection and remote valve chambers that are not connected to the Station Earth).

12.2.2 Station Safety Earth

In cases where a new Station Safety Earth Mat is required to be provided, the following specifications shall apply for pricing:

The **Earth Mat** shall consist of a completely buried, lattice network of 40x3mm, bare copper tape. All the crossover points of the lattice shall be braised or cadwelded and protected with PVC insulation tape. Buried joints or splices shall not be clamped or bolted. The earth mat shall be buried, 1000mm minimum, below finished grade.

The interconnecting conductors shall be radially interconnected to form a common earthing system, for all electrical equipment, lightning protection and static earthing in accordance with relevant SABS requirements.

If required, additional earth electrodes may be installed to achieve the specified resistance, of the

common earthing system to the general mass of earth. Where earth rods are paralleled in a group to reduce the earth resistance to the permissible value, they shall be spaced apart for a distance at least equal to their buried depth length.

During the contract, the earth mat design shall be in accordance with IEEE80.

12.3 Switchgear Room Building and Equipment

12.3.1 A Main Safety/Electrical Earth Bar comprising of a copper bar, 50mm x 5mm min shall be installed in the basement/false floor of the Switchgear Room. Where possible, this Earth Bar shall be designated as the Primary Test Point for the station earthing system with the following equipment directly connected:

- **Station Earth Mat.** Where possible, a minimum of four separate connections shall be taken into the Switchgear Room via separate routes from the Earth Mat, by means of 40mm x 3mm Cu Earth tape. Connection to the Main Safety Earth bar shall be made in two places by means of 70mm², 600-volt class, green colored, PVC insulated, stranded copper conductor, to facilitate testing of the Earth System.
- **Transformers.** By means of 70mm², 600-volt class, green colored, PVC insulated, stranded copper conductor
- **MV/LV Panels.** By means of dual 70mm², 600-volt class, green colored, PVC insulated, stranded copper conductors
- **Generator.** By means of 70mm², 600-volt class, green colored, PVC insulated, stranded copper conductor
- **Instrument Earth.** By means of dual 70mm², 600-volt class, green colored, PVC insulated, stranded copper conductors
- **Manifold Earth.** By means of dual 70mm², 600-volt class, green colored, PVC insulated, stranded copper conductors

Note that on existing sites, the earth mat has been connected to the station earthing system in multiple places (namely; the Switchgear Room, Control Room and Manifold), and thus designation of a single Primary Test point is not possible. Multiple test points have thus been defined as follows: Switchgear Room, Control Room and Manifold Mainline Pumps 1 & 4 (where possible).

12.3.2 All secondary earthing within the substation shall be attached to this station earth bar at appropriate demarcated points.

12.4 Control Room Building and Equipment

12.4.1 A secondary Safety/Electrical Earth Bar comprising of a copper bar, 50mm x 5mm min shall be installed in the basement/false floor of the Equipment/Control Room in an easily accessible position. Where possible, this Earth Bar shall be directly connected to the Main Safety/Electrical Earth bar located in the Switchgear Room, by means of dual 70mm², 600-volt class, green colored, PVC insulated, stranded copper conductors.

Note that all marshalling and equipment panels shall have an electrical earth bar, separate from an insulated instrument earth bar, installed and to which all electrical equipment earths shall be connected.

12.4.2 An Instrument Earth Bar comprising of a copper bar, 50mm x 5mm min shall be installed in the basement/false floor of the Equipment/Control Room in an easily accessible position. Where

possible, this Earth Bar shall be directly connected to the Main Safety Earth bar located in the Switchgear Room, by means of dual 70mm², 600-volt class, green colored, PVC insulated, stranded copper conductors.

Note that all marshalling and equipment panels shall have an insulated instrument earth bar, separate from the electrical earth bar, installed and to which all clean/instrument earths shall be connected.

12.4.3 Instrument and Electrical Earth systems shall be clearly labelled.

12.5 Manifold Area and Equipment

12.5.1 All manifolds shall have an insulated manifold earthing system installed, comprising of the following specifications:

- 40mm x 3mm min flat copper tape, to run the entire length of the main electrical racking reticulation and supported off of insulators at distances of no more than 2m apart. Use of existing electrical racking reticulation supports shall be permitted. All joints will require to be braised. Earthing reticulation shall be installed in such a manner so as to be unobtrusive and yet accessible and shall be positioned so as to avoid obstruction to walkways and access routes.
- The Manifold Earth bar shall be connected to the main safety/electrical earth located in the Switchgear Room, by means of dual 70mm², 600-volt class, green colored, PVC insulated, stranded copper conductors.

Note that on existing sites, the earth mat has been connected to the earthing system in multiple places (namely; the Switchgear Room, Control Room and Manifold), and thus designation of a single Primary Test point is not possible. Secondary test points have thus been defined where possible as follows: Switchgear Room, Control Room and Manifold Mainline Pumps 1 & 4.

12.4.2 All process plant and equipment located within the manifold area shall be attached to this manifold earth bar at appropriate demarcated points, via appropriately sized insulated PVC copper cable (green/yellow colored insulation), as follows:

- All electrical equipment shall be earthed via two separate earths, namely via the power cable earth core back to the respective Starter Panel electrical earth bar, and secondly via a separate visual earth from the motor frame to the manifold earth bar. Use of cable armouring as an earth conductor is not acceptable.
- All instrument stands and field junction boxes shall be separately earthed via means of an insulated 16mm² min PVC copper cabling.
- All process vessels (tanks, vessels and piping) and racking reticulation shall be earthed via insulated 70mm² min PVC copper cabling in two separate places.

All earth conductors utilized shall comprise of stranded, PVC insulated copper conductors with crimped cable lugs. All connections shall be fitted with a "star" or serrated washer in addition to the backnut, to ensure good earth contact.

12.6 Earth System Identification Standards

12.6.1 Earth Bar Labels

Earth bars shall be clearly labelled according to their functionality (e.g. "EB xx" to denote an electrical earth bar, "IB xx" to denote an instrument earth bar, where xx denotes a unique consecutive number). The Functional Identifier "EB 00" shall always denote the Station Earth Mat.

In addition, earth bars designated as Test Points shall be labelled accordingly.

Labels shall comprise of the Traffolyte engraved type, and fixed by means of stainless steel screws. Finish shall comprise of black letters against a white background, with text 40mm height.

Labels shall be readable/visible after the wiring has been done.

12.6.2 Earth cable Identification

Earth cables may be divided into two types, namely primary earth cabling running from subsystem earth bars directly or indirectly to the main station earth (and used for testing purposes), and secondary earth cabling running between the subsystem earth bars and equipment or infrastructure.

Only Primary earth cabling (i.e. those used for testing purposes) is required to be identified, by means of a Functional Identifier denoting both source and destination earth bars.

Identification numbers will comprise of the following specification:

- Grafoplast Targa Metal TGT System (Carrier Rail 58mm in length) 316 Stainless Steel Markers, with punched text 6 mm height minimum, fastened onto the cable at both ends via means of Stainless Steel cable ties

Examples:

EB01 – EB00 Cable Identifier for Earth cable running between Electrical Earth bar EB01 and the Station Earth Mat

IB01 – EB00 Cable Identifier for Earth cable running between Instrument Earth bar IB01 and the Station Earth Mat

12.7 Testing

12.7.1 Earth Resistivity and Electrode Testing

It will be the Contractors responsibility to carry out all necessary earth resistivity tests on site, where applicable. Tests will be in accordance with the requirements of BS 1013 as amended.

After all earth electrodes/trench earth's have been installed, an earth megger shall be used to test the earth resistance at the earth bar or connection point to the main station earth and the results recorded. Note that all ECC connections, and any other bonding material shall be disconnected from the earth connection point whilst the earth is being tested.

Earth Continuity Testing.

Earth continuity readings shall be measured and recorded from the earth bar to each item of equipment and process plant, and shall include all piping, vessels, transformers, motors, actuators, switchgear cabinets, marshalling enclosures and instrumentation.

12.7.2 The following are the maximum acceptable earth electrode resistances:

Electrical Earth

- a) Main substation - 1 ohm
- b) Miniature substations and kiosks - 2 ohms
- c) Highmasts - 5 ohms.

Instrument Earth

- a) Instrument Earth - < 1 ohm

13.0 INSPECTION AND GUARANTEE

- 13.1 Transnet Projects reserves the right to inspect the installation and the equipment to be used.
- 13.2 All lightning protection systems shall be inspected and certified by an accredited person after completion of the installation, to verify conformance as required by Code of Practice, SANS 10313.
- 13.3 All components of the lightning protection system shall be inspected to ensure that they are in good condition and are capable of performing their designed functions.
- 13.4 The tenderer shall ensure that all elements of the electrical installation have been incorporated into the protected space by bonding or extensions to the lightning protection system.
- 13.5 The mechanical condition of all conductors, bonds, joints and earth electrodes shall be checked and the observations noted. .
- 13.6 The tenderer shall undertake to repair and replace all faults and faulty materials due to bad workmanship during a period of six months.
- 13.8 The tenderer shall be required to guarantee the installation for a period of twelve (12) months.

END

SIGNATURE OF TENDERER:

DATE:

**TRANSNET PROJECTS
DESIGN SERVICES**

TECHNICAL SPECIFICATION:


Specification No. TPD: 007-MVSWITCHSPEC

**SPECIFICATION FOR INDOOR MEDIUM/ HIGH VOLTAGE
(1KV TO 33 KV) ALTERNATING CURRENT SWITCHGEAR
AND CONTROL GEAR**



Technical Specification
Specification No. TPD: 007-MVSWITCHSPEC

SPECIFICATION FOR INDOOR MEDIUM/ HIGH VOLTAGE (1KV TO 33 KV) ALTERNATING CURRENT SWITCHGEAR AND CONTROL GEAR

REVISIONS		
REV	DATE	APPROVED
	01/11/2024	

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1. SCOPE

“Where the document states “Transnet Group Capital, the name should read as Transnet Port Terminals”.

This specification covers Transnet Group Capital requirements for the supply, delivery, and installation of indoor, high voltage, 3 phase, 50-hertz switchgear and control gear in the range 1 kV to 36 kV as detailed in **Appendix 1** “Schedule of Requirements”.

2. REFERENCE LIST

The following publications and documents (latest edition) are referred to herein.

Note: We suggest that IEC standards are used, which allows the greatest selection of reputable suppliers and does not favour any particular supplier. For voltages above 11kV most switchgear is in any case imported and standards other than IEC standards are generally excluded.

2.1 International Electro Technical Commission

IEC PUBLICATION 62271-100 High-voltage alternating current circuit breakers.

IEC PUBLICATION 60060 High-voltage test techniques.

IEC PUBLICATION 62271 Specification for AC metal enclosed switchgear and control gear, for voltages above 1kV up to and including 52kV

Part:

- 1 Common specifications for HV switchgear and control gear standards (IEC 60694)
- 100 Alternating current Circuit breakers (IEC60056)
- 102 Alternating current disconnectors and earthing switches (IEC 60129)
- 103 Switches for rated voltages above 1kV and less than 52kV (IEC60265-1)
- 106 Alternating current contactors and contactor-based motor-starters (IEC60470)
- 200 AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV

IEC PUBLICATION 60027-7 Electrical drawing symbols used.

IEC PUBLICATION 60243 Recommended methods of test for electric strength of solid insulating materials at power frequencies.

IEC PUBLICATION 60282 High-voltage fuses.

IEC PUBLICATION 62271-200 High-voltage metal enclosed switchgear and control gear.

IEC PUBLICATION 62271-103 High-voltage alternating current fuse-switch combinations and fuse-circuit-breaker combinations.

IEC PUBLICATION 60051 Direct acting indicating electrical measuring instruments and their accessories.

IEC PUBLICATION 62271 -106 High-voltage switchgear and control gear - Part 106: Alternating current contactors, contactor-based controllers and motor-starters

IEC PUBLICATION 60071 Insulation coordination

- IEC PUBLICATION 60282-1 Protection fuses
- IEC PUBLICATION 60529 Degree of protection (IP rating)
- IEC PUBLICATION 60044-1 Current transformer
- IEC PUBLICATION 60044-2 Voltage transformer

IEC PUBLICATION 60044-8	Current sensors
IEC PUBLICATION 60044-7	Voltage sensors
IEC PUBLICATION 61343-5	Voltage detection system VDS
IEC PUBLICATION 60071-1	Insulation coordination
IEC PUBLICATION 60125	Protection relays
IEC PUBLICATION 60376	SF6 gas

- 2.2 The equipment offered shall comply with the latest editions of the relevant International Electro-technical Commission.
- 2.3 Users of this specification must ensure that they are in possession of the latest issues of the above-mentioned standards.

3. INFORMATION AND METHOD OF TENDERING

- 3.1 Tenderers shall submit their main offers/details of plant in accordance with the requirements of this specification. Deviations from the requirements of this specification which are of a minor nature and do not depart materially, will be considered at the discretion of Transnet Projects. The acceptance of alternative tenders will be considered only if a main tender is submitted as per this specification. Note, this specification will form part used to assess the substantive responsiveness of the bid and the submission of offer will be used for the assessment.
- 3.2 The "Technical Data Sheet" forming Appendix 2 of this specification shall be completed in detail, for each offer. Alternative offers shall be clearly marked "Alternative Offer No. _____".
- 3.3 All documents forming part of the Tender shall be firmly bound. No loose documents will be considered.
- 3.4 Failure to comply with the above requirements may preclude a tender from consideration.
- 3.5 All tender documents shall be presented in a clear format with index, uniquely numbered pages and cross-referenced. The total number of pages shall be clearly stated in the index.
- 3.6 **Type test reports/certificates shall be issued or certified by the appropriate test authority, that is accredited according to ISO/IEC 17025.**

4. APPENDICES

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

- 4.1 **Appendix 1 - Schedule of Requirements.**
This appendix details special requirements.
- 4.2 **Appendix 2 - Technical Data Sheet.**
This appendix calls, for specific technical information to be furnished with tenders. All Technical Data Sheets shall be signed by the Tenderer and returned as part of the tender. Failure to comply may result in a tender being excluded. This submission shall include the details of the form of offer, this is to say, the tenderers shall submit the drawing, preferably a preliminary shop/plant structural drawing, showing the details of the offer. This will be used to assess the compliance to the scope.

- 4.2.1 Equipment offered in this appendix shall be supplied in terms of this specification and no changes or substitutes will be allowed without the written consent from Transnet Group Capital.
- 4.2.2 Acceptance by Transnet Group Capital of the equipment offered in this appendix, in no way relieves the tenderer of his obligation to fulfil his statement of compliance with the specification.
- 4.2.3 This appendix is used during adjudication of tenders to assess the equipment offered.
- 4.2.4 The tenderer is responsible for the accuracy of information submitted in this appendix.
- 4.4 **Appendix 3 - "Test Requirements".**
This appendix contains Transnet Group Capital requirements with respect to type and routine test certificates and test procedures.
- 4.5 **Appendix 4 - "Statement of Compliance"**
This appendix shall be completed by all tenderers and signed. Where tenderers do not fully comply, all deviations shall be clearly indicated in the space provided or by means of a covering letter. **Failure to complete the statement of compliance will result in tenders being excluded.**

5. AMBIENT/ENVIRONMENTAL CONDITIONS:

The equipment shall be designed and rated for continuous operation under the following conditions:-

Altitude....	Sea level.
Ambient temperature....	-5 C to +40 C (daily average +35 C).
Relative humidity....	As high as 95%.
Lightning conditions .	Severe, with a maximum lightning ground flash density of 11 flashes per km ² per annum.
Atmospheric conditions....	Salt laden as well as industrial atmosphere. Electrolytic corrosion conditions prevail in all areas owing to the proximity of direct current traction systems and cathodic protection schemes.

6. DRAWINGS AND INSTRUCTION MANUALS

- 6.1 All drawings shall be in accordance with SANS 10111 – Engineering Drawings.
- 6.2 The successful tenderer shall supply the following instruction manuals, all of which shall be included in the tender price and be to the satisfaction of Transnet Group Capital:
- 6.2.1 Structural Drawings
- Structural drawings shall be completely dimensioned, showing:
- Arrangement.
 - Plan, front view, and other elevation views if pertinent.

- Required clearances for opening doors and for removing breakers.
- Conduit or cable entrance locations for bottom entrance.
- Busbar locations and configurations.
- Incoming and outgoing cable termination positions.
- Anchor bolt locations.
- Earthing connections.
- Mass of equipment. Individual mass of stationary units and breakers, if shipped separately.
- Foundation holding down bolting details showing mounting rails and run-out rails for draw-out circuit-breakers.

6.2.2 One Line Diagrams

One-line diagrams shall show:

- Instrument transformers
- Relays with their ANSI device numbers.
- Meters and meter switches.
- Other pertinent devices.

6.2.3 Schematic Diagrams

Schematic wiring diagrams shall be furnished for each different electrically operated breaker control scheme and show the following:

- All control devices and device contacts, each of which shall be labelled with its correct ANSI device function number, or reference.
- Device terminal numbers, terminal block numbers and terminal numbers.
- All internal interconnections, bus wiring, inter panel wiring and connections to external equipment.
- Relay internal logic configuration
- Protection relay setting sheet

6.2.4 As-Built Drawings

6.2.4.1 On completion of installation and commissioning of the relevant equipment, the originals of the above drawings shall be updated by the equipment supplier to reflect the as-built status.

6.2.4.2 The supplier shall then also provide Group Capital with three copies of all relevant CAD data for drawing records and drawing reproduction. The drawings must be in a format that can be read by AutoCAD 2000, format (“dwg” or “dxf” format).

6.2.5 Maintenance Manuals

6.2.5.1 On completion of installation and commissioning of the relevant equipment, the contractor shall submit three copies of the equipment maintenance manuals in both hard copy and electronic format. (The electronic format must be in Microsoft “Word”, or .pdf format)

6.3 The maintenance manuals shall include all the necessary information on electrical and electronic equipment to enable the maintenance staff to fully comprehend the function of the equipment and to maintain service and repair the equipment. In order to comply with this condition, the following information (as applicable) shall be included in the manuals:



- 6.2.6 Complete circuit diagrams.
- 6.2.7 System Block or Logic Diagrams.
- 6.2.8 Test Procedures (Flow Chart form preferred) and information to enable testing such as voltage values and tolerances, waveforms, polarities etc.
- 6.2.9 Component lists, which shall contain complete electrical information and standard identification in respect of all components, unless this is indicated directly on diagrams.
- 6.2.10 A complete description of the electronic equipment, including the function of all input and output points, maintenance and calibration procedures, reference to special test instruments required, etc.
- 6.3 All symbols used on diagrams shall be in accordance with IEC Publication 60027-7 wherever possible. A legend shall be supplied for all symbols that do not appear in the IEC Publications.
- 6.4. All information submitted in manuals should be clearly cross-referenced, indexed and accurately descriptive of the equipment provided. All filed changes to equipment shall be incorporated in the updated diagrams/sheets before expiry of the guarantee period.
- 6.5 Photocopies of original material shall only be acceptable if these are clearly legible and preferably colour copies.
- 6.6 A preliminary copy of the maintenance manual shall be forwarded to Transnet Group Capital for approval prior to issue and in advance of the delivery of equipment.
- 6.7 **Late submission of drawings, manuals and instructions shall incur delivery penalties on the full contract price. The contract will only be deemed to be complete on reception of all drawings, manuals and instructions.**

7. SWITCHGEAR AND CONTROLGEAR

7.1 General

- 7.1.1 All switchgear and control gear shall be designed, manufactured and tested in accordance with the recommendations of IEC PUBLICATION 298, IEC 62271-100, IEC 62271-200 and IEC 62271-102. The switchgear panels shall be of arc proof, AFLR rated, stainless steel, air insulated, free standing, extensible type, containing power busses, earthing bus, withdrawable (to be used as a standard for the bid process) or fixed type (with three suggested and clear visible indicators for breaker position, fixed type to be considered as an option during contract only and not for bidding purposes), completely screened busbars and terminations, sealed and protected from water and dust, auxiliary control devices, instrument transformers, modern SCADA compatible protection relays fitted in the panel LV compartment and control switches. They shall be supplied complete with all necessary terminal plates, cable glands for cable entry, wiring trunking for LV wiring and multi core cables.
- 7.1.3 The switchgear and control gear shall be of the air-insulated, indoor, modular, free standing, cubicle type housing with a minimum 316 stainless steel with a thickness of 2mm, powder coated with a minimum thickness of 50µm to the colour as specified in the detail specification.



- 7.1.3 The switchgear and control gear panels shall be bolted together to form a continuous, self-supporting, and self-contained switchgear and control gear board of uniform appearance capable for extension at both ends with similar panels.
- 7.1.4 Access to the current transformer and cable terminations shall be from the rear of the panels.
- 7.1.5 All cubicles shall be so constructed by means of modular design to ensure inter-changeability of all components of the same type between different panels.
- 7.1.6 All removable plates shall be secured by means of bolts and nuts. All bolts, nuts, washers fixing equipment etc. shall be stainless steel. Nuts shall be either welded in position or secured by means of a mechanical fixing device. Self-tapping screws will not be considered.
- 7.1.7 High-voltage and low-voltage equipment shall be housed in separate compartments.
- 7.1.8 The busbars shall be completely screened and contained in a separate compartment.
- 7.1.8.1 There shall be no barriers down the busbar runs except on either side of the busbar section switch. Barriers shall not be used to provide mechanical support for busbars or connections.
- 7.1.8.2 Entry through barriers between cubicles shall be via purpose designed bushings.
- 7.1.9 Each switchgear panel shall be a self-contained unit with a minimum degree of protection of IP54 for indoor installations.
- 7.1.10 The pollution level (IEC 186) shall be taken as "Medium" (creepage distance of 20mm/kV) for all equipment installed indoors or inside enclosures.
- 7.1.11 The panels shall be built to withstand internal faults and shall be based on IEC 62271-200. In the event of an internal arc fault, a person standing at the front, rear or alongside the panel shall not be burnt or electrocuted.
- 7.1.11.1 A means of pressure relief shall be provided and the tenderer shall describe in full the method used.
- 7.1.11.2 Vent outlets, if used, shall be suitably designed to prevent accidental inward opening.
- 7.1.12 The rated insulation levels shall be in accordance with, the recommendation of IEC PUBLICATION 298 Appendix EE test 2.
- 7.1.13 Fault-make integral earthing shall be provided to earth the circuit on the cable side of all switching devices.
- 7.1.14 Where separate earthing switches are used, they shall be so interlocked as to prevent operation when the main circuit is closed.
- 7.1.15 Fault-make integral earthing on the busbar side shall be provided for each busbar section. The busbar-earthing device shall be interlocked to prevent the earthing of an energized busbar. The earth switch can be located in the bus section / bus riser, or dedicated busbar earthing cubicle. If required the busbar earth switch can be located in the same cubicle as the busbar VT.

- 7.1.16 Where separate earthing switches are provided the switching devices shall be capable of earthing either the cable or busbar side.
- 7.1.16.1 The earthing switching device will be tested at the routine testing of the switchgear as specified in this specification.
- 7.1.17 Integral earthing shall be capable of being padlocked in the earthed position.
- 7.1.18 An earthing bus shall be provided for the entire length of the board and shall provide connection points at each panel section. The cross-sectional area of the earthing conductor shall be such that the current density shall not exceed 200A/mm² under the specified earth fault conditions. Provision will be made for solder-less connectors for 70mm² copper cables.
- 7.1.19 All compartment doors giving direct access to high voltage equipment shall be mechanically and electrically interlocked so that the door cannot be opened whilst the equipment is alive.
- 7.1.20 Each switching device panel shall be fitted with "close" and "open" controls. Where "close" and "open" pushbuttons protrude to the outside of panel they shall be of the shrouded type.
- 7.1.21 Means shall be provided for easy inspection and maintenance of the switchgear and control gear.
- 7.1.22 Applied insulation shall be in intimate contact with conductors and conductor joints to obviate voids.
- 7.1.23 Anti-condensation 230 Volt heaters shall be provided for each individual compartment and the bus bar chamber of each switch-gear. A switch shall be provided to control the heaters.
- 7.1.23.1 A thermostatically controlled switch, adjustable between 10°deg.C and 40°deg. C, shall be provided in the supply circuit to the heaters. An over-riding switch shall be provided for the thermostat.
- 7.1.23.2 The wiring from the heater elements to terminals shall be high temperature insulation covered. A suitable compression type gland shall be fitted for an incoming 230V supply.
- 7.2 The successful tenderer shall supply all material required to assemble the switchgear on site.
- 7.3 Two copies of all type and routine test certificates shall be supplied in accordance with NRS 003 for all equipment in the panels as applicable.

8. WITHDRAWABLE SWITCHGEAR AND CONTROLGEAR

- 8.1 Suitable indication shall be provided to mechanically indicate the position of the switching device, i.e. racked-in, racked-out (isolated), earthed, on/off. The indication shall be readily visible from the front of each panel.
- 8.2 Each switching device shall be mounted on a transporting truck device, and fitted with wheels.
- 8.3 Connection and disconnection of the switching device shall be by means of suitable contacts mounted on robust insulators.
- 8.4 In addition to interlocks recommended in IEC PUBLICATION 62271-200 the following shall be provided.

- 8.4.1 Separate shutters shall be provided to cover the "Busbar" and "Circuit" high-voltage sockets. These shutters shall automatically cover the sockets with a positive action when the switching device is withdrawn. The shutters shall be equipped with a fail-safe device to prevent their manual opening when the circuit breaker is removed from the compartment and the door is open.

In addition to the above.

- 8.4.1.1 Facilities shall be provided for independently padlocking each shutter in the closed position.
- 8.4.1.2 Busbar shutters shall be red (colour D29 in CKS 279) and shall be clearly marked "Busbars". The "Circuit" shutters shall be yellow (colour D26 in CKS 279) and shall be marked "cable".
- 8.4.1.3 Provision shall be made for testing the operation of the switching device when fully withdrawn from the panels.
- 8.5 non-withdrawable switchgear shall only be offered if called for in Appendix 1 A of this specification or will only be considered in an event where a stringent requirement of this specification is only possible in a fixed pattern.
- 8.6 LSC type in accordance with IEC62271-200 shall apply. LSC2B shall apply for withdrawable switchgear and LSC2A shall apply for non-withdrawable switchgear, as called for in Appendix 1.
- 8.7 Partitioning shall be in accordance with IEC 62271-200. For withdrawable switchgear PM shall apply, for non withdrawable switchgear PI shall apply.
- 8.8 All operations shall be from the front of the switchgear from behind closed doors. No part of any operation / racking / shutter actuation shall be allowed with the door open or partially open.
- 8.9 The internal arc capability of the switchgear shall be in accordance with IEC62271-200 Appendix 1, and rated at AFLR, for the short circuit current for a duration of 1 second.
- 8.10 The switchgear shall be fitted with an arc vent duct that will contain the internal arc and safely vent the arc within the switch room or vent to the exterior of the switch room. The manufacturer should access each installation and make recommendations based as to the most suitable option for the switchgear installation. The manufacturers recommendations should be supported by a calculation that will calculate the pressure rise in the room, consider the room volume, and design fault level.

9. SWITCHING DEVICES

9.1 General requirements

- 9.1.1 All switching devices shall be ganged triple pole.
- 9.1.2 The method of securing the moving contact to the armature shall feature a safety device in addition to the normal securing mechanism.
- 9.1.3 A thermal overload device in addition to the low voltage circuit protection shall protect all motors used for spring charging or other applications.



- 9.1.4 Tripping shall be by means of trip coils.
- 9.1.5 Electrically held tripping mechanisms shall not trip due to transients or voltage dips to zero for 10 cycles or 70% of the rated voltage. This is not applicable when tripping occurs due to protective system operation.
- 9.1.6 Tripping mechanisms operating on power failures shall restore the switching device to the condition prior to the power failure.
- 9.1.7 If a direct means of indicating contact wear and the necessity for replacement is not provided, a concise description of how this can be determined shall be provided on a label permanently fixed to the switching device or switch panel.
- 9.1.8 Two spares normally open and two spare normally closed auxiliary contacts shall be provided on each switching device. The spare contacts shall be wired to a terminal strip in the panel. For withdrawable switchgear and control gear auxiliary plugs and sockets shall be used.

9.2 Circuit -Breakers

- 9.2.1 The insulation and arc-quenching medium will be vacuum or SF6.
- 9.2.2 Circuit breakers shall be designed manufactured and tested in accordance with IEC PUBLICATION 62271-100. The 50Hz electrical ratings of the circuit breaker shall be in accordance (or better) than the data listed in the manufacturer's data sheet.
- 9.2.3 The circuit breaker shall be of the vertical or horizontal isolating, draw out type. Where trolleys are required to remove circuit breakers, VT's or Contactors from the panel, at least two trolleys of each size / type per substation will be provided as standard operating equipment to facilitate swapping of similar equipment.
- 9.2.4 The control mechanism of the circuit breaker shall be of the spring assisted trip free type with anti-pumping circuitry. The circuit breaker shall be equipped with mechanical tripping and closing in addition to electrical trip and close.
- 9.2.5 The first pole to clear factor shall be 1,5.
- 9.2.6 The making time shall not be greater than one second.
- 9.2.7 Rated insulation level for circuit breakers shall be in accordance with IEC 62271-100 and will be listed in the data sheet.
- 9.2.8 Interlocking shall be provided to prevent connecting the circuit breaker to, or disconnecting it from the bus stabs unless the circuit breaker is open.
- 9.2.9 Barrier shutters shall be provided which effectively close the bus stab disconnect openings when the circuit breaker is withdrawn. These shutters will be pad lockable and clearly marked to indicate the primary circuit, i.e. Busbar, Cable, Left Busbar or Right Busbar. Facilities shall be provided for independently padlocking each shutter in the closed position.
- 9.2.10 All compartment doors giving direct access to high voltage equipment shall be mechanically interlocked so that the door cannot be opened whilst the equipment is live.

- 9.2.11 Suitable indication shall be provided to mechanically indicate the position of the switching device, i.e. racked-in, racked-out (isolated), earthed, on/off.
The indication shall be readily visible from the front of each panel.
- 9.2.12 Circuit breakers shall have the following class rating, in accordance with IEC 62271-200
Extended Electrical life rating of E2
Extended mechanical life of rating M2
Very low re-strike probability or rating C2
- 9.2.13 Circuit breakers shall have stored energy mechanisms. Where spring assisted stored energy mechanisms are provided these shall be charged by means of a motor. For magnetic actuated circuit breakers the stored energy device shall be charged via an electronic controller. In both cases the circuit breaker may not be able to be closed until there is sufficient energy in the stored energy mechanism to enable the breaker from being opened immediately. The circuit breaker closing and opening mechanisms must not consume more than 750 W of power peak during opening or closing operations.
- 9.2.14 It shall be possible to mechanically trip the circuit breaker with the CB door closed.

9.3 Switch Disconnectors (Isolators) and Earthing Switches

- 9.3.1 All disconnectors and earthing switches shall be designed, manufactured and tested in accordance with the recommendation of IEC PUBLICATION 62271-102.
- 9.3.2 Integral type circuit test facilities shall be provided on all switch-disconnectors.
- 9.3.3 Earth switches shall be rated for the same fault ratings as the circuit breaker and busbars.
- 9.3.4 The busbar earthing shall be interlocked to prevent earthing of an energised busbar.
- 9.3.5 The integral earthing shall be capable of being padlocked in the earthed position.
- 9.3.6 Both the cable circuits as well as busbars shall be provided with fault-make rated earthing switch, unless otherwise approved. Each busbar section shall be provided with its own earthing switch.
- 9.3.7 The type of operation shall be independent manual.
- 9.3.8 The operating mechanism shall be positioned on the front of the panel and be lockable in all switching states. Reliable mechanical indication of these states shall be visible from the front of the panel.
- 9.3.9 Earth switches shall be equipped with mechanical and electrical interlocking to prevent:
- Closing a cable earth switch unless the circuit breaker is open and disconnected from the bus stubs.
 - Reconnection of the circuit breaker to the bus stubs if the earth switch is closed
 - Closing the circuit breaker
- 9.3.10 A notice bearing the following inscription shall be provided adjacent to the operating mechanism:
"DO NOT OPERATE UNDER LOAD"

10. BUSBARS

- 10.1 All busbars shall be designed, manufactured, marked and tested in accordance with BS 159.
- 10.2 The busbars shall be bolted, modular screened, air Insulated and contained in an isolated compartment.
- 10.3 Busbars shall be made from electrical grade high conductivity hard drawn copper, capable of carrying the continuous rated current as specified in the detail specification, without exceeding the maximum temperature rise specified in the relevant Standard.
- 10.4 The busbars shall be mechanically braced for the asymmetrical ampere rating and duration of the circuit breaker having the highest interrupting rating. There shall be no barriers down the busbar runs except on either side of the busbar section switch. Barriers shall not be used to provide mechanical support for busbars or connections. Entry through barriers between cubicles shall be via purpose-designed bushings.
- 10.5 All joints and tees in busbars shall be made with high tensile stainless-steel bolts, nuts and washers, securely tightened with a torque wrench to the manufacturers specified torque settings. These settings shall aim to minimise contact resistance and avoid distortion and / or hardening of the copper due to overstressing.
- 10.6 Insulated bushings shall comply with SABS 1035.

11. BUSHINGS

- 11.1 All bushings shall be designed, manufactured, and tested in accordance with SABS 1035.

12. CABLE BOXES, GLANDS, AND TERMINATIONS

- 12.1 All cable end boxes shall be suitable to terminate (sizes up to a maximum of 185mm² wire armoured cable). Cable termination compartment shall be suitable for an equal or similar approved to EN50181, inner-cone, pluggable cable termination arrangement.
- 12.2 Cable armouring shall be insulated from the board with insulating material which shall withstand 4 kV or greater for one minute when tested in accordance with IEC PUBLICATION 60071.
- 12.2.1 Insulated gland plates with substantial links or straps connected to the earth terminal shall be provided for bonding the cable sheath and armouring to the earth conductor of the boards.
- 12.3 Cables shall terminate using a plugged type and the switchgear shall be air-insulated compartments and manufactured ready for the arrangement.
- 12.4 Adequate space shall be allowed from the cable terminations to facilitate connecting onto the boards.
- 12.4 The termination box switchgear shall be manufactured with the female plugs to accommodate the screened plugged type termination manufactured to EN50181.

13. INSULATING MEDIUM

13.1 The insulation medium will be vacuum or SF6, refer to Annexure 1

14. HIGH-VOLTAGE FUSES

- 14.1 All fuses shall be designed, manufactured and tested in accordance with the recommendation of IEC PUBLICATION 60282.
- 14.2 Integral three pole earthing facilities to earth both sides of the switching device shall be provided unless otherwise approved.
- 14.3 All fuses shall be of the air insulated, cartridge, striker pin type.
- 14.4 Parallel connection fuse cartridges shall not be used unless no single fuse cartridge of the same characteristic is available.
- 14.5 Integral type circuit test facilities must be provided.

15. CURRENT TRANSFORMERS

- 15.1 Current transformers shall comply with the requirements of SABS IEC 60044/1 shall be tested in accordance with the following procedure:
- Each unit must be pre-stressed at 1,04x line voltage and the peak discharge measured at 1,1x the phase voltage.
 - The discharge level shall not exceed 50 pC for a wound primary and 10 pC for a bar primary.
 - A representative from Transnet Group Capital shall witness this test, unless routine test certificates, issued by a recognised independent testing authority, are submitted.
- 15.2 Short circuit ratings and voltage classes shall match the ratings of the associated circuit breaker and the current transformers shall also be rated to ensure the correct operation of the equipment constituting the burden.
- 15.3 Current transformers shall be of accuracy class 3 for measuring purposes be of accuracy class 0,2 for metering purposes and be connected to the cable side and be fitted with a 10 amp test winding. Testing windings shall be fitted on the higher current ratio of multi-ratio transformers.
- 15.4 All current transformers will have a permanent thermal current carrying rating of a minimum of 120% of the maximum specified ratio.
- 15.5 The limits of temperature rise of the windings of the current transformers at the full load continuous primary current rating of the switchgear panel shall comply with SABS IEC 60044.
- 15.6 Ring type current transformers shall have separate insulation between live conductors of the main circuit and inner surface of the current transformers. This insulation shall be capable of withstanding the high voltage test as specified. A rigid system of mounting shall be used to ensure that concentricity is

maintained.

- 15.7 All current transformers shall be naturally air-cooled. Their secondary terminal connections shall be safely and readily accessible with the circuit isolated. The current transformers in a switchgear panel shall be readily accessible with only the circuit-side isolated for removal/replacement without extensive dismantling of primary circuits.
- 15.8 The secondary rating of the transformer shall be either 1 or 5 amp as required by the protection or metering equipment.
- 15.9 All terminals of the current transformers shall be terminated individually into terminals in the LV compartment to facilitate changing of ratio's or the star point. The current transformer neutral earthing point will be taken through an earthing link located in the LV compartment.
- 15.10 Each current transformer shall be connected to test block with shorting strips located on the LV compartment door.
- 15.11 Unless specified, each current transformer shall be equipped with a test winding, terminated in the LV compartment, on terminals equipped with test plugs to allow for easy testing. Test winding terminals shall be clearly marked
- 15.12 Each current transformer rating (VA, ALF, V_{kp} etc) shall be decided and calculated by the manufacturer to meet the protection requirements. Manufacturers shall provide proof of the calculations. The values given on appendix 1 schedule of requirements shall be taken as typical values.

16. VOLTAGE TRANSFORMERS

- 16.1 All voltage transformers shall be designed, manufactured and tested in accordance with SABS IEC 60044/2.
- 16.2 Dry type cast epoxy resin insulated voltage transformers of the withdrawable type shall be provided for protection and metering purposes. When isolated the plug connections on the switchboard shall be fully shrouded by means of automatic shutters with padlocking facilities.
- 16.3 Where directional protection elements are required, voltage transformers shall be of a single phase or five limb construction, star/ star/ residual open delta connected, with primary neutral earthed and secondary neutral earthed via an earthing link in the LV compartment. Ratios shall be:

$$\frac{V_L}{\sqrt{3}} : \frac{110}{\sqrt{3}} : \frac{110}{3}$$

A suitable anti Ferro-resonance device shall be fitted to the open delta winding to prevent any Ferro resonance voltages that may occur.

- 16.4 The voltage transformers shall be successfully tested in accordance with the following procedure:
- Each unit shall be pre-stressed at 1,04 x line voltage and then the peak discharge measured at 1,1 x the phase voltage. This discharge level shall be less than or equal to 100 pC. A representative from Transnet Group Capital shall witness this test, unless routine test certificates, issued by a recognised independent testing authority are submitted.
- 16.5 Voltage transformers secondary shall have the following minimum accuracy classes :

- 16.5.1 Indicating instruments - 3
- 16.5.2 Protective systems - 6P
- 16.5.3 Metering - 0,2

- 16.6 The primary of the voltage transformer shall be connected to the busbar side through high-voltage fuse-links.

- 16.7 Voltage transformers shall be fitted with three pole moulded case circuit breakers for protection of the secondary winding. The MCB's shall be mounted in the LV compartment of the panel

- 16.8 Phase or neutral earthing of the secondary winding through a removable link shall be provided. No fuses or miniature circuit breakers shall be fitted in this connection to earth.

- 16.9 The burden shall be suitable for the connected load but shall be not less than 25 VA per phase.

- 16.10 Where voltage transformers are fitted these shall be inside the arc proof enclosure. If voltage transformers are fitted outside the arc proof enclosure these shall be fully screened type. The arc capability of the switchgear must not be de-rated due to fitting of voltage transformers. Suitable documentary proof shall be provided for the design to prove compliance to the internal arc capability of the switchgear.

- 16.11 Busbar VT's shall be rackable type from behind a closed door. Busbar VT's can be situated in the bus riser cubicle, and if necessary a dedicated VT cubicle shall be supplied. Cable VT's shall only be accessible once the cable circuit is de-energised and a cable earth applied.

17. INDICATING LIGHTS AND INSTRUMENTS

- 17.1 All indicating instruments shall be designed, manufactured and tested in accordance with IEC 60051.

- 17.2 All indicating instruments shall have the following features:
 - 17.2.1 be flush-mounted and dustproof.
 - 17.2.2 be of minimum accuracy class 2,5.
 - 17.2.3 have a scale length of not less than 85 mm.
 - 17.2.4 be provided with zero adjustment from the front without requiring dismantling of the indicating instrument.
 - 17.2.5 be marked with the ratios of the associated current and/ or voltage transformers.

- 17.3 Ammeter full-scale shall be the first standard value above the normal primary current rating of the associated current transformers.

- 17.4 Voltmeter full-scale deflection shall indicate nominal voltage at approximately 75% of the scale length and shall be marked with a red line.

- 17.5 Maximum demand ammeters shall be of the 15 minute thermal type and shall be integrated with the indicating ammeters.

- 17.6 All panels will be equipped with cluster LED type lights on the panel door indicating:
 - Circuit Breaker Open

- Circuit Breaker Closed

- 17.7 All earth switch position statuses will be clearly indicated with LED type semaphores or on the protection relay LCD graphical display.
- 17.8 All alarms and trip conditions will be clearly indicated via either programmed LED's on the protection relay or an alarm annunciator.
- 17.9 A capacitive integrated voltage indicator for permanent monitoring of all three line voltages for "cable live", and "busbar live" indication shall be provided on each panel.
- 17.10 The voltage indicators shall comply with IEC 61243-5, consisting of flashing LED diodes deriving its power directly from the primary system via capacitive coupling electrodes. Test points shall provide for phasing and phase rotation checks.

18. ENERGY METERS

- 18.1 Energy meters shall be designed, manufactured, installed and tested in accordance with BS 37.

19. PROTECTIVE SYSTEMS AND RELAYS

- 19.1 Protective relays shall be designed, manufactured, and tested in accordance with IEC Publication 60125.
- 19.2 Protective relays shall have been type tested to verify performance and safety. Proof of these tests in the form of type test certificates shall be included in tender documents.
- 19.3 Standing load calculations for the all the protection schemes as supplied shall be calculated and submitted with the tender to allow for Battery charger sizing.
- 19.4 Unless otherwise stated in Appendix 1, each relay shall:
- 19.4.1 Have an error class index of 5.
 - 19.4.2 Have an operating time class index of 60.
 - 19.4.3 Have a rated number of contact operations with electrical duty class index N3.
 - 19.4.4 Have a mechanical stability class index S2.
- 19.5 Each Relay shall:
- have at least t over current elements
 - be rated in conjunction with its associated current transformer(s), to withstand the over current in the secondary winding of the current transformer/s under fault conditions
 - be continuously rated for any current setting
 - be clearly marked with the current ratio of the current transformer associated there-with
 - Have contacts rated to make and carry the current of their associated circuits. The trip coil current shall be interrupted by auxiliary contacts on the circuit breaker.
 - have manual reset and flag indications for the protection function that operated

- have an additional set of normally open and normally closed contacts, or auxiliary relays, for remote indication of the relay operation. The contacts shall be capable of handling 50 W in the range of 24 to 110 V DC, and shall be wired to a terminal strip at the back of the panel.

19.6 Microprocessor based digital protection relays with the following features

- A graphical display depicting the status of the devices connected to the protection relay
- A delay closing function as part of the CB control
- Clearly labelled LED indication
- Web server functionality
- Local Remote selection
- Disturbance and event recordings
- Time synchronization
- Communication protocol and SCADA requirements shall be in accordance with the TNPA Automation Control Standard.

19.6.2 Digital relays shall incorporate PT100 RTD inputs where required.

19.6.3 Where microprocessor based relays are supplied, communication cables and software will be supplied to configure the protection relays.

19.7 Over-current and Earth Fault Relays

19.7.1 The relays shall have the time/current characteristics as specified below

- IEC Normal inverse.
- IEC Very inverse.
- IEC Extremely inverse.
- IEC Definite Time

19.7.2 The relays shall have current settings adjustable either infinitely or in not less than equal steps in the following ranges:

Overcurrent Low Set	10% to 500%
Overcurrent High Set	10% to 4000%
Overcurrent Instantaneous	100% to 4000%
<hr/>	
Earth Fault Low Set	10% to 500%
Earth Fault High Set	10% to 4000%
Earth Fault Instantaneous	100% to 4000%

Where 100% corresponds to the secondary rating of the current transformer specified.

19.7.5 Sensitive earth fault relays shall have at least a current setting of 2% - 3% and an operating time adjustable from 2 - 10 seconds.

19.8 Differential Pilot Wire Feeder Protection

19.8.1 Only to be used where a communication medium (pilot wires or fibre optic) exists or can be installed between the ends of the cable.

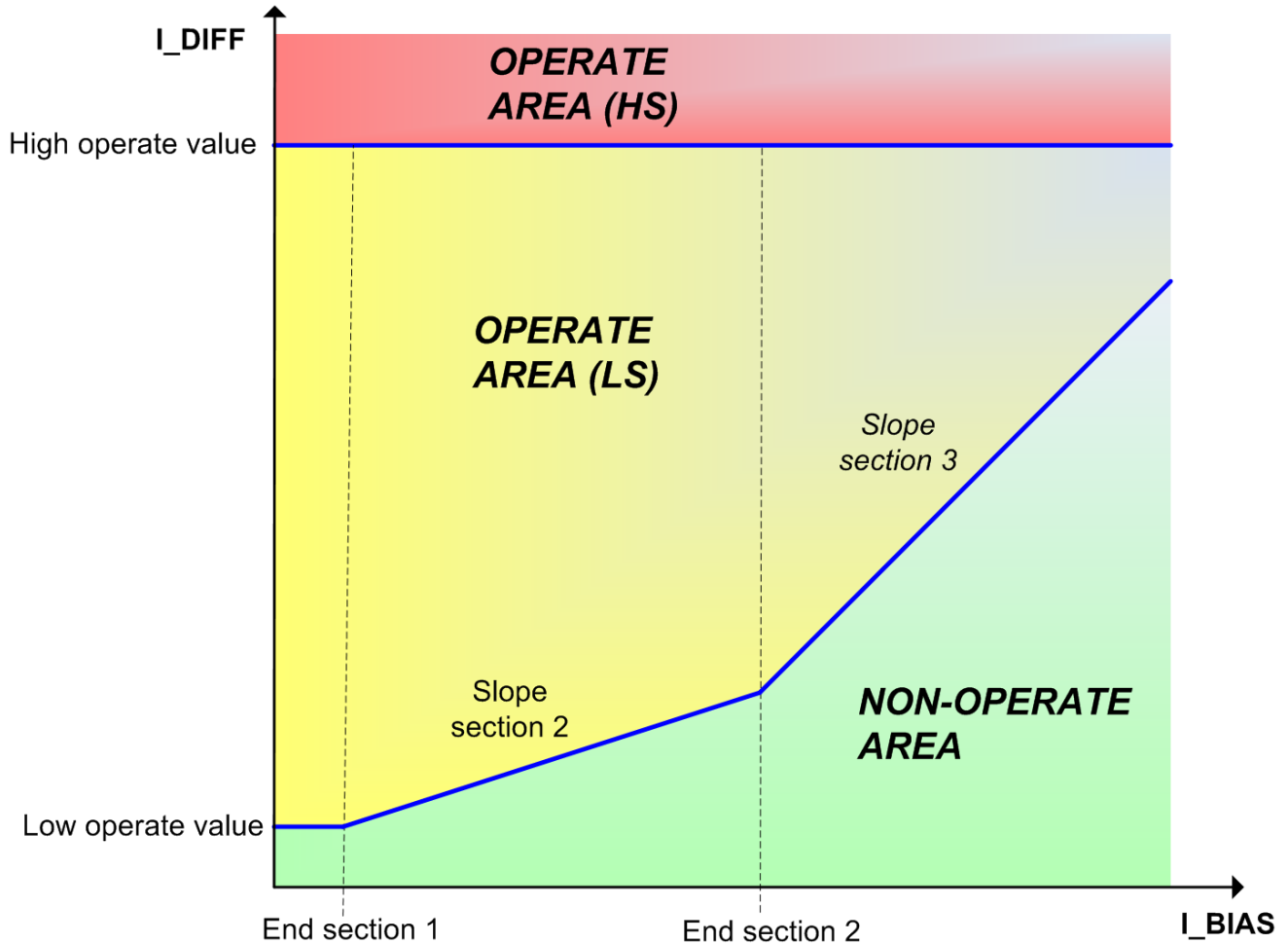


Figure 1

19.8.2 Relays incorporated in this system shall have a setting range of between

- I diff restrained 10% to 500%
- I diff un restrained 10% to 500%
- CT compensation 20% to 500%

They shall be compensated for any inherent out-of-balance in the current transformers supplied and shall be automatically biased against tripping on through-faults.

19.8.3 It shall be the responsibility of the tenderer to ensure that the current transformers and relays supplied will match exactly the equipment installed at the other end of the cable to be protected and that the whole protective system will be stable on through-faults but will operate satisfactorily on feeder faults.

19.9 Arc Protection and Busbar Blocking Scheme.

19.9.1 A combination of Arc Protection and a Busbar blocking scheme shall be used to detect busbar fault under the following 3 conditions:

- Earth faults
- Phase to Phase faults.
- Three Phase faults.

19.9.2 The switchgear protection “Zones” must be split over two sections

19.10 Arc protection

19.10.1 The individual zone relays shall trip all the switching devices in their respective zones to isolate the fault from all sources of supply.

19.10.3 The reaction time of the busbar protection system shall be such as to limit the duration of an internal arc fault to the withstand capability of the board.

19.10.4 Each relay shall:

19.10.4.1 Have its current setting adjustable in not less than seven equal steps
Overcurrent 50% to 600%

Earth Fault 5% to 50%

where 100% corresponds to the secondary rating of the current transformer specified.

19.10.4.2 Tripping the Incomers and sections directly and loading Input on the feeder breakers to clear to zone

19.11 Transformer Protection - (3 phase, 2 winding power transformers)

19.11.1 Over-current and Earth Fault Protection relays shall consist of the following elements:

The relays shall have the time/current characteristics as specified below

- IEC Normal inverse.
- IEC Very inverse.
- IEC Extremely inverse.
- IEC Definite Time

19.7.2 The relays shall have current settings adjustable either infinitely or in not less than equal steps in the following ranges:

Overcurrent Low Set	10% to 500%
Overcurrent High Set	10% to 4000%
Overcurrent Instantaneous	100% to 4000%
<hr/>	
Earth Fault Low Set	10% to 500%
Earth Fault High Set	10% to 4000%
Earth Fault Instantaneous	100% to 4000%

Where 100% corresponds to the secondary rating of the current transformer specified.

19.11.2 Relays provided for Restricted Earth Fault Protection of Star Windings shall be of the Low impedance instantaneous type and shall be tuned to 50 Hz.

19.11.2.1 Stability on through faults shall be maintained up to the fault rating of the switchgear.

19.11.2.2 Sensitivity shall be equal to the rated current of the current transformer.

19.11.2.3 The current transformer, to be installed in the neutral connection of the power transformer, shall be supplied and installed.

19.11.2.4 The insulation of the neutral current transformer shall be equal to the rated voltage of the switchgear.

19.11.2.5 The tenderer shall advise the maximum load burden.

19.11.2.6 The current transformer for the neutral connection of the power transformer shall be installed by the Tenderer, who shall be responsible for the correct operation of the complete protective system.

19.11.3 Biased Differential Protection relays shall have a high speed characteristic and be biased to provide stability during through faults. They shall not be operated by normal magnetising inrush currents.

19.8.2 Relays incorporated in this system shall have a setting range of between

- I diff restrained 10% to 500%
- I diff un restrained 10% to 500%
- CT compensation 20% to 500%
- Vector group Compensation
- Harmonic restraint

19.11.3.1 Current transformers for the higher voltage winding of the power transformer will be installed by others but the tenderer shall advise the maximum load burden.

19.11.4 Over temperature, Gas Detection and Overpressure Protection shall be provided unless otherwise stated in Appendix 1. All circuit breakers controlling transformers shall be provided with the following instantaneous trip auxiliary relays:

- One relay for over-temperature protection.
- One relay for Buchholz or over-pressure protection.

19.11.5 The circuit-breaker panel shall be provided with an instantaneous type relay for protection against Tank-earth faults.

19.12 Electrical Inter-Trip

19.12.1 When electrical inter-tripping between two circuit-breakers is specified in Appendix 1 and/or on the relevant drawings, tripping of the driving unit shall close a set of contacts, to instantaneously energise the trip circuit of the follower unit.

19.12.2 All circuit breakers, controlling transformers shall be provided with the equipment specified above for driving units.

20. CLOSING AND TRIPPING SUPPLIES

20.1 A battery and battery-charging unit when specified in Appendix 1 shall be supplied, with the switchboard. The battery shall be capable of providing 8 hours standby time in the event of loss of supply. The battery shall be charged via a constant voltage charger that is supplied from a 220VAC supply. The charger shall be sufficiently rated to deliver the average 24hr standing load as well as the battery charging current for a discharged battery. The charger and battery shall have a 20% overcapacity to cater for aging and unforeseen loads. The manufacturer shall provide a preliminary calculation with the tender that shall be finalised on design approval.

21. TEST TERMINAL BLOCKS

21.1 Readily accessible, suitably enclosed test terminal blocks (equal or similar approved to MMLG/MMLB type) shall be provided on the front panel of each switch unit for the purpose of testing all protective systems.

21.2 Test terminal blocks need not be provided for frame protection system if the associated current transformers are mounted externally.

21.3 The test blocks shall be wired to the protective relays and associated current transformers.

22. CONTROL SWITCHES

22.1 All control switches shall be designed manufactured and tested in accordance with the recommendation of IEC PUBLICATION 337.

22.2 Rotary pistol grip type switches shall be used on electrically operated switching devices.

22.3 The electrical and mechanical endurance of the control switches shall not be less than 100 000 operations.

23. MINIATURE CIRCUIT-BREAKERS

- 23.1 Miniature circuit breakers shall be designed, manufactured and tested in accordance with SANS 156 and shall be mounted in the relay compartment and be readily accessible.

24. LOW VOLTAGE WIRING

- 24.1 Internal LV wiring shall be multi-strand copper conductor with PVC insulation having a minimum insulation rating of 600V/1000V to SANS 1411. When subjected to movement, the wiring shall be fully flexible with a minimum of 40 strands (2.5mm²).
- 24.2 Wiring shall be enclosed in a metal conduit when in the high voltage compartments.
- 24.3 Insulated crimp terminal lugs shall be used to terminate all wires. Lugs shall be correctly crimped to the lug manufacturers' specification.
- 24.4 All wiring from heaters to terminals shall be heat resistant.
- 24.5 Wiring shall be suitably strapped and enclosed in flexible conduit when looping from panels to doors and shall be continuous without joints.
- 24.6 Current transformer star points on secondary windings shall be earthed in the immediate vicinity of the transformer as well as onto the main circuit earth.
- 24.7 Terminal blocks or strips shall have a minimum of 10% spare terminals for future additions and be of the box type incorporating a pressure pad between the conductor and clamping screws.
- 27.8 LV wiring shall be colour coded and the ends of every wire shall be numbered as per NWS 1958 and in accordance with the approved schematic diagrams. Wiring shall also be neatly done and suitably strapped or housed in wire channels. Ferrule numbers shall be oil and moisture resistant.
- 24.9 Unless otherwise specified, the following guideline will be followed:
- DC Circuits (Indication and control) 1.5mm² Grey
 - DC Circuit (Spring rewind motor) 2.5mm² Grey
 - AC Circuits (VT) 1.5mm² Colour coded
 - AC Circuits (1A CT) 4mm² Colour coded
 - AC Circuits (5A CT) 4mm² Colour coded
 - AC Circuits (Panel Heaters) 2.5mm² Black
 - AC Circuit (Cable Live Indicators) 1.5mm² Colour coded
 - DC Buswiring (Supply) 4mm² Grey
 - AC Buswiring (Supply) 4mm² Black
 - DC Buswiring (Signalling) 1mm² Screened

25. REMOTE CONTROL

- 25.1 All electrically operated switching devices shall be equipped with circuits for remote operation and indication.

- 25.2 The circuits shall include the following :
- TWO set of N/O and N/C auxiliary contacts to indicate the "open" or "closed" states of the switching device.
 - Relays for remote closing and opening shall require a maximum of 50 watts at 110 Volts DC.

25.3 All remote circuits shall be wired to a terminal strip at the back of the panel.

Selectors switch on the front of the panel to select between "local" and "remote" operation.

25.4 An additional socket shall be allowed for at the front of the panel for remote operation via a handheld pendant type remote control unit (chicken switch).

26. ARC DUCTING

26.1 The switchgear should be fitted with arc ducting to safely vent the gases away from the operator, to the outside of the building.

26.2 The arc ducting can be vented into the sides of the switchgear or two the rear of the switchgear. The manufacturer must determine the most suitable venting arrangement for his switchgear from the substation drawings.

26.3 If arc ducting cannot be vented to the exterior of the building then the arc ducting can vent into the switch-room through an absorber.

26.4 The design of the switchgear arc ducting system must be supported by type test certificates.

26.5 If the arc ducting is fitted with an absorber then the pressure rise within the switch-room must be determined by means of a calculation.

26.6 The maximum height of the arc ducting should be 2600 mm from the floor to the top of the switchgear including the arc ducting.

27. NAMEPLATES AND LABELS

27.1 Labelling shall be done according to NRS 003. Graphic symbols for wiring diagrams shall comply with NRS 002.

27.2 Each switchgear and control gear panel shall be fitted with a nameplate in a conspicuous position indicating:

Maker's name:	Maker's type number
Maker's serial number:	Client contract number
Service voltage:	Number of phases
Continuous rating:	Rating kA seconds

27.3 Identical nameplates as that on all current and voltage transformers shall be mounted in a conspicuous position inside the relay compartment. The phase colour with which each current/voltage transformer is associated shall appear beneath each nameplate.



- 27.4 Interchangeable, engraved labels, showing panel designation (circuit breaker number and circuit name), shall be fitted to the front and the rear of the fixed part of each cubicle and associated withdrawable equipment for easy identification.
- 27.5 Only screws with nuts or rivets shall be utilized to fix label. Self-tapping screws or similar will not be used.
- 27.6 All equipment shall be clearly designated in position in accordance with the wiring and schematic drawings.
- 27.7 Voltmeter labels shall state whether busbar or cable voltage is indicated.
- 27.8 All labels shall be made of composite sandwich type plastic material with black lettering on white background. Letters must be of sufficient size to be clearly legible. All nameplates and labels shall be in English.
- 27.9 Danger Notices: White lettering on red background. Letters must be of sufficient size to be clearly legible.

28. PAINTING

- 28.1 All surfaces of the distribution board shall be light orange to SANS 1091 colour No. B26.
- 28.2 All surfaces shall be cleaned according to the appropriate method described in SANS 064 for the particular surface to be cleaned, the contamination to be removed and the primer to be applied.
- 28.3 Blast cleaning of components shall be in accordance with clause 4.3 of SANS 064 to a degree of cleanliness of at least Sa2 for inland exposure components and Sa 1/2 for coastal exposure components. See Table 1 of SANS 064 for the appropriate profile.
- 28.4 Sheet metal that cannot be blast cleaned shall be cleaned by pickling according to clause 4.6 of SANS 064.
- 28.5 Components that will be powder coated shall be cleaned and prepared by the surface conversion process according to clause 5 of SANS 064 to a medium-weight classification of table 2 of that specification.
- 28.6 Oil and accumulated dirt on steel components where no rusting is present shall be removed according to clause 3 of SANS 064.
- 28.7 The powder-coating process shall be in accordance with SANS 1274 type 4: Corrosion-resistant coatings for interior use and using the thermosetting type high gloss coating.
- 28.8 All specified coatings shall be applied according to the relevant specification and the manufacturer's instructions shall be followed.
- 28.9 Coatings shall not be applied under conditions that may be detrimental to the effectiveness of the coating or the appearance of the painted surface.
- 28.10 When examined visually the finished products shall have a uniform appearance as far as gloss is concerned and shall show no sign of damage. Damaged areas shall be repaired coat for coat to obtain the desired finish.

29. TESTS

- 29.1 All prescribed tests as referred to in the standard specifications may be called for at the discretion of Transnet Group Capital.
- 29.2 Transnet Group Capital also reserves the right to carry out any check tests on the equipment.
- 29.3 Notwithstanding the successful completion of tests, the tenderer will still be responsible for the efficient operation of the equipment.
- 29.4 The tenderer shall bear all costs for any tests that will be required.

30. INSPECTION

- 30.1 The successful tenderer shall advise Transnet Group Capital at least four (4) weeks in advance of panel testing to enable Transnet Group Capital to witness the testing at the manufacturer's premises once Switchboards are 100% ready before shipment.
- 30.2 All transport cost to enable Transnet Group Capital personnel to attend such test must be included in the tenderers price (Max. 2 persons)
- 30.3 In the event of major faults ie; wiring discrepancies, VCB'S failed to trip; busbar earthing device not demonstrated on the day, the successful tenderer shall again arrange for a retest at the tenderer cost.

31. TOOLS AND APPLIANCES

- 31.1 One set of any special tools and appliances required for normal operation and maintenance shall be supplied with each board.

32. SPARES

- 32.1 The tenderer shall state whether their local representatives hold a complete range of spares in stock as and when required.
- 32.2 The tenderer shall submit a separate quote for recommended spares for maintenance purposes of supply a detailed description of each item including manufacturer's catalogue number.
- 32.3 A complete spare parts list, including parts location diagrams or drawing and prices, which the manufacturer recommends for the first two years' operation, shall be submitted with the tender.
- 32.4 A separate list detailing items likely to be used in a 10-year period shall also be submitted with the tender.

33. PACKING



- 33.1 The equipment shall be packed in such a manner that it will be protected during handling and transport by road, rail or sea as applicable. The movements of instruments, meters and relays shall be protected against vibration damage during transit.
- 33.2 When sea transport is involved, a dehydrating agent shall be provided where necessary.

34. GUARANTEE

- 34.1 The tenderer shall guarantee the equipment supplied by him in terms of this specification for a period of one year after successful completion of hot commissioning of the plant. The tenderer shall state his compliance herewith.
- 34.2 This guarantee shall cover all materials, parts, workmanship, performance and efficiency (normal wear and tear excluded). The guarantee shall include all equipment supplied.
- 34.3 If any part/equipment fails during the 12-month guarantee period, the supplied shall immediately replace such part/equipment free of charge.

WITNESSES


- 1.
.....
TENDERER
- 2.
.....
DATE

**Transnet Projects
Design Services**

TECHNICAL SPECIFICATION:

Specification No. TPD-009-STANDBYPLANTSPEC

**SPECIFICATION FOR DIESEL GENERATOR
SYSTEMS**

	Specification No: TPD-009- STANDBYPLANTSPEC	Engineering
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Title: **SPECIFICATION FOR DIESEL GENERATOR**

SYSTEMS

Unique Identifier:


Area of Applicability: **Engineering**

Documentation Type: **Standard**

Revision: **1**

Total Pages: **63**

Next Review Date:

Prepared by:  2025/08/10
 Samukelo Magcaba (Electrical) Date 2025/11/11


Siva Naidoo (Electrical) Date
 PP 2025/11/11

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1. Introduction

The document is required to provide the baseline requirements for new Diesel Generator systems to be used within the Transnet Port Terminals. It also provides a standardised approach when defining the user or site- specific requirements for Diesel Generator systems.

2. Supporting Clauses

2.1 Scope

This standard covers the design, testing, supply, delivery to site, erection, and commissioning requirements for Diesel Generator (DG) Systems.

2.1.1 Purpose

To provide the minimum technical requirements for DG systems used in Transnet Port Terminals.

2.1.2 Applicability

This document shall apply throughout Transnet Port Terminals.

2.2 Normative/Informative References

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

- [1] ISO 9001 Quality Management Systems.
- [2] BS 5514-5, Reciprocating internal combustion engines: performance -Part 5: Torsional vibrations.
- [3] ISO 3046, Reciprocating internal combustion engines.
- [4] NFPA 850, Recommended practice for fire protection for electric generating plants and high voltage direct current converter stations
- [5] Act No. 85 of 1993, Occupational Health and Safety Act
- [6] SANS 342, Automotive diesel fuel
- [7] SANS 1186, Symbolic safety signs
- [8] SANS 1507, Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3300 V)
- [9] SANS 1632, Batteries
- [10] SANS 1652, Battery chargers – industrial type
- [11] SANS 8528, Reciprocating internal combustion engine driven alternating current generating sets (all parts)
- [12] SANS 10089, The Petroleum Industry: Storage and distribution of petroleum products in above- ground bulk installation

- [13] SANS 10140, Identification colour marking.
- [14] SANS 60034, Rotating electrical machines.
- [15] SANS 60529, Degrees of protection provided by enclosures.
- [16] SANS 60947, Low-voltage switchgear and control gear – Part 7-1: Ancillary equipment – Terminal blocks for copper conductors
- [17] SANS 10142, Wiring of Premises
- [18] 240-56227516, Specification for LV switchgear and control assemblies and associate’s equipment for voltages up to and Including 1 000 V AC and 1 500 V DC
- [19] 36-1126, Specification for corrosion protection of plant and equipment with coatings
- [20] 32-333, Standard for Electronic Protection and Fault Monitoring Equipment for Power Stations

2.3 Definitions

2.3.1 General

Refer to [11] SANS 8528-1 and [14] SANS 60034-1 for definitions relevant to this document.

2.3.2 Disclosure classification

Controlled disclosure: controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Table 1: Abbreviations

Abbreviation	Description
AC	Alternating Current
AVR	Automatic Voltage Regulator
BIL	Basic Insulation Level
CAP	Committee for Accepted Products
CCA	Cold Cranking Amps
COP	Continuous Power
DC	Direct Current
DCS	Distributed Control System
DG	Diesel Generator
ESP	Emergency Standby Power
FAT	Factory Acceptance Test
HMI	Human–Machine Interface
HV	High Voltage
IP	International (Ingress) Protection
ISO	International Organization for Standardization

LAP	List of Accepted Products
LCD	Liquid Crystal Display
LED	Light-emitting Diode
LTP	Limited-time running power
MCCB	Moulded Case Circuit-breaker
n/a	not applicable
NFPA	National Fire Protection Association
OEM	Original Equipment Manufacturer
OHSA	Occupational Health and Safety Act
P	Proportional
PI	Proportional Integral
PID	Proportional Integral Differential
PRP	Prime Power
rpm	revolutions per minute
SAE	Society of Automotive Engineers
SANS	South African National Standards
SAT	Site Acceptance Test
SC	Steering Committee
THD	Total Harmonic Distortion
VAR	Volt-Ampere Reactive

2.5 Roles and responsibilities

This document shall be used whenever diesel generators are procured for Transnet Port Terminals purposes.

2.6 Process for Monitoring

The engineering Department shall ensure that this document is maintained.

2.7 Related/Supporting Documents

This document is to be used in conjunction with the following:

- a) Application-specific Design Guide (where available)
- b) Employer's Specification for Works which will contain the plant-specific Operating and Control philosophy.
- c) Supporting AB Schedules

3. Requirements

3.1 General

- a) The DG shall be built in accordance with the latest revisions of [11] SANS 8528, except where deviations are specified in this document and its accompanying Schedule A and Schedule B. All brand named component shall be read as equal of similar approved.
- b) Where deviations exist between this document; its accompanying Schedule A, Schedule B and [11] SANS 8528, the order of precedence is as follows: accompanying Schedule A and Schedule B; followed by this document; and then [11] SANS 8528.
- c) The system shall be designed to run free of excessive vibration and noise under all conditions of load and speed, and shall comply with the requirements of [14] SANS 60034 and [2] BS 5514-5.
- d) All moving and rotating parts shall comply with the requirements of the Occupational Health and Safety Act (OHSA) [5] Act No. 85 of 1993.
- e) The Genset shall be of the integrated self-contained, super silent sound attenuated canopy type with self bunding base tank. The canopy should be a minimum 3CR12 grade of steel.

3.2 Application and operating philosophy

- a) DGs will be generally used at the following sites:
 - Transnet Port Terminals sites
 - Substations
 - Office buildings
 - Cranes
- b) The generator configuration will be generally used for mobile applications unless specified differently in Schedule A.
- c) The DG will generally be used for extended backup unless specified differently in Schedule A.
- d) The Specification is only applicable to AC generating sets.

3.3 Site conditions

- a) The DG shall be designed for use inland or coastal as specified in Schedule A.
- b) The DG System shall be designed for a maximum ambient temperature of 50 °C.
- c) The following conditions shall be specified in Schedule A:
 - 1) Minimum ambient temperature
 - 2) Altitude
 - 3) Humidity
 - 4) Air quality (dust or sand)
 - 5) Marine environment
 - 6) Shock and imposed vibration

- 7) Chemical pollution
- 8) Radiation
- 9) Cooling water/liquid

3.4 Reliability

- a) The DG System shall be designed for an operating life of 20 years under the specified operating conditions in Schedule A.
- b) A warranty of minimum 5 years and 10000 operating hours is required from the engine manufacturer, with an included maintenance plan for the period, with real time data and predictive alert functionality with all software provided and integrated together with the unit.
- c) A warranty of 5 years is required from the alternator manufacturer, with an included maintenance plan for the period, with real time data and predictive alert functionality with all software provided and integrated together with the unit.
- d) Any deviation from this shall be clearly indicated.

3.5 Maintainability

- a) The DG System shall be designed to minimize the need for maintenance.
- b) Whether preventative or predictive, where maintenance is required, the design shall provide for good ergonomics to make it as easy as possible, with due consideration given to personnel safety.
- c) The design shall allow for modular replacement of assemblies and components to a level as low as possible.
- d) The time to isolate a faulty component shall be reduced by making extensive use of built-in test facilities.
- e) Component conditions that may lead to a failure shall be monitored, and an alarm condition generated.
- f) Spares and parts availability shall be guaranteed for the designed life of the DG.
- g) Warranty on any part of the system shall be at least two years unless specified differently in Schedule A or otherwise in this document.
- h) All safety requirements to enable fueling whilst running (refuel on the fly) shall be included in the design of the genset.

3.6 System definition

The overview of a typical DG system is defined in in more detail in the clauses following the table.

Table 2: System definition – overview

Diesel Engine (prime mover)	Alternator	Control and switchgear	Auxiliaries	Mechanical build
<ul style="list-style-type: none"> • Engine rating • Speed • Governor • Emissions • Deutz/Cummins/Volvo Penta 	<ul style="list-style-type: none"> • Type • Excitation • Power Output • Voltage and Frequency • Marelli 	<ul style="list-style-type: none"> • Equipment for the control, switching, operation, monitoring, and alarming of the generating set shall be part of the associated control gear and switchgear systems • Comap Intelligen 1000 autosynchronising paralleling controller 	<ul style="list-style-type: none"> • Starting system • Air intake and exhaust gas systems • Cooling systems • Lubricating oil system • Fuel system (including fuel treatment where applicable) • Auxiliary electrical power supply • Earthing 	<ul style="list-style-type: none"> • Base frame • Coupling • Enclosure • Fire detection • Canopy-Type • Integrated Self bunding base tank

3.6.1 Diesel Engine

3.6.1.1 General

- The diesel engine shall be of the diesel fueled, cold starting, water-cooled , speed-governed type.
- Engine Preheater and Pre-start Lubricating Oil Pump (Prelube Pump) are required..
- The supplier shall state in Schedule A, the guaranteed specific fuel consumption of the complete set with all auxiliary equipment at full load, three-quarter load, and half load to

accuracy within 5%.

- d) The fuel consumption shall be determined in accordance with [3] ISO 3046-1, and given in litres per kilowatt hour (l/kWh). The supplier shall also make reference to lubricating oil consumption.

3.6.1.2 Rating

- a) The engine shall be suitably rated to provide the required power output from the generator, even under impact loading when all pre-impact loads are connected.
- b) The generator start-up time (as specified in [11] SANS 8528-1) shall be specified in Schedule A.
- c) The engine shall deliver full load in accordance with [3] ISO 3046-1, within the starting period, and under the specified environmental conditions.
- d) De-rating shall be in accordance with [3] ISO 3046-1.
- e) The engine performance classification shall be Continuous Power (COP), Prime Power (PRP), Limited time running power (LTP) or Emergency Standby Power (ESP) as defined in [11] SANS 8528-1 and as specified in Schedule A.
- f) The required mounting type and Generating set configuration shall be in accordance with [11] SANS 8528-1 and specified in Schedule A.
- g) The required Performance Class as defined in [11] SANS 8528-1 and load type are also given in Schedule A. If no performance class is specified, a G3 class shall be assumed.
- h) Where the employer does not declare a duty type, the supplier shall assume that duty type S1 (continuous running duty) applies.
- i) The power rating shall be expressed in kilowatts at rated frequency and a power factor of 0,8 lagging unless otherwise stated in Schedule A.
- j) The output of the engine under the specified site conditions shall be the net available output power after allowance has been made for all auxiliary equipment (i.e. parasitic losses) including air filter, radiator fan, oil pump, water pump, battery charger alternator, governor, etc.
- k) It shall be possible to operate the DG with a lagging Power Factor from 0,8 up until Unity, depending on the active power demand, unless otherwise stated in Schedule A.
- l) The DG shall be capable of performing a single load step equal $\geq 50\%$ of the continuous kilowatt (kW) rating of the machine while remaining within operating limits.
- m) The DG shall be capable of performing a single load step equal to 110% of the most severe single step load in the plant design profile.
- n) The DG shall accept the load without voltage collapse or engine stalling and recover to normal operating speed.
- o) The supplier shall document the voltage and frequency deviation observed.
- p) The supplier shall supply with the tender all technical data with de-rating graphs on altitude of all engines. This shall form part of the engine sizing.

3.6.1.3 Governor

- a) The engine shall be fitted with an electronic governor to provide speed control in accordance with the requirements of [3] ISO 3046-4 and [11] SANS 8528-1.
- b) The governor shall be of the Proportional Integral (PI) or Proportional Integral Differential (PID) type as specified in Schedule A.

3.6.1.4 Speed

An engine operating nominal speed of 1 500 rpm is preferred, except where it is otherwise stated in Schedule A.

3.6.1.5 Emissions

Any emission (noise, vibration, heat, gas, and electromagnetic disturbance) limits as specified by applicable legislation relating to the protection of the environment and to the health and safety of personnel operating or maintaining the generating set shall be specified in Schedule A.

3.6.2 Alternator (Generator)

3.6.2.1 Type

- a) The alternator shall be of the brushless type and comply with the relevant requirements of [14] SANS 60034-1, [14] SANS 60034-8, [14] SANS 60034-9 and [11] SANS 8528-3, and with the additional requirements specified.
- b) Where the Employer's Engineer does not declare a duty type, the supplier shall assume that duty type S1 (continuous running duty) applies.

3.6.2.2 Excitation

- a) Whether a permanent magnet is required for excitation shall be specified in Schedule A.
- b) The method of excitation, the excitation voltage range and the maximum field control current shall be provided.
- c) Series current boost (consisting of controls and current transformers) shall be provided, if required, to meet transient voltage response performance.

3.6.2.3 Heaters

- a) The alternator shall be fitted with one or more anti-condensation heater elements to protect those components that can be adversely affected by moisture.
- b) The heater shall be approved by the alternator supplier.
- c) The heater's power requirement shall be stated.

3.6.2.4 Power Output

- a) The Employer's Engineer shall specify the required output power requirements in kilovolt-ampere (kVA) and the power factor.

- b) The rated output is the apparent power at the terminals and shall be expressed in kilovolt-ampere (kVA) together with the power factor.
- c) The supplier shall specify the short-circuit rating of the alternator. The alternator shall comply with the requirements of section 5.2 of [11] SANS 8528-3 in respect of short-circuits.
- d) The alternator's efficiency at full load, 3/4 load, 1/2 load and 1/4 load at unity and at 0.8 lag power factors shall be stated in Schedule A.
- e) The continuous current capabilities and the regulation percentages shall be stated in Schedule A.

3.6.2.5 Loading

- a) Linear and non-linear loads shall be started as per the Starting Sequence detailed in Schedule A and the load schedules.
- b) The alternator shall be suitable for supplying the following types of loads:
 - 1) Linear loads, such as lighting circuits and motors.
 - 2) Non-linear loads, such as saturable-reactor controlled rectifiers, six-pulse or 12-pulse controlled thyristors, Variable speed drives or stop/start control systems.

3.6.2.6 Voltage and Frequency

- a) The nominal voltage and frequency, including tolerances, shall be as stated in Schedule A. The terminal voltage shall be adjustable over the specified range.
- b) The generator voltage shall remain within the limits specified from no-load to full-load at unity, and at 0,8 lag power factors, inclusive of diesel engine speed drop of 4% and temperature drift.
- c) The maximum permissible voltage drop and frequency variation for the maximum load step should be maintained within the specified limits as stated in Schedule A.

3.6.2.7 Type of Construction

- a) Details shall be provided of the bearings offered.
- b) The alternator shall be air-cooled.
- c) The alternator insulation class for its different parts shall be as specified in Schedule A.

3.6.3 Control, Monitoring, Alarms, Indications and Switchgear

3.6.3.1 General

The Employer's Engineer shall provide the Employer's Specification for Works which will contain the Operating and Control philosophy for the electrical plant system. This will include operating scenarios (test functionality, test load, shut down, breaker status, etc) in a Matrix table.

- a) The control system shall comply with the requirements of [11] SANS 8528-4, and shall be electrically fail-safe.

- b) The control system shall be powered from Direct Current (DC) available from the engine cranking batteries.
- c) The control system shall be capable of operating on an alarm-only basis or alarm and shut down, if so required.
- d) All data shall be date and time stamped.

3.6.3.2 Control Panel Controls

- a) The DG control panel shall provide local control of most of DG functions.
- b) As a minimum, the local control panel shall include the following. Any or all the functions can be available from a local Human–Machine Interface (HMI).
 - 1) Local Start
 - 2) Local Stop
 - 3) Emergency Stop
 - 4) Raise/Lower Load (when synchronized)
 - 5) Raise/Lower Volt-Ampere Reactive (VAR)
 - 6) Breaker Selection (Generator or Paralleling)
 - 7) Initiate Sync Command
 - 8) Remote/Local
 - 9) DG Breaker Trip and Close Functions
 - 10) Raise/Lower Voltage
 - 11) Raise/Lower Speed
 - 12) Alarm Accept/Test/Reset
 - 13) Lamp Test
 - 14) Local/Remote Control
 - 15) Mains Circuit-breaker operation
 - 16) Generator Bus Breaker (if parallel units)
- c) The sync function shall utilize the Comap Intelligen 1000 Autosynchronising paralleling controller
- d) Manual sync capability (including sync scope and sync lights) shall not be provided unless specifically requested in Schedule A.

3.6.3.3 Control Panel Features

- a) The following features shall be included in the control panel. Any or all of the functions can be available from a local HMI:
 - 1) Analogue Alternating Current (AC) Metering panel: Provides a colour-coded display of generator set output, voltage, current, frequency, power factor and kilowatt (kW).

- 2) Graphical Data Display: Allows the operator to view all engine and alternator data; to perform operator adjustments for speed, voltage, and time delays; and to view fault history.
 - 3) Light-emitting Diode (LED) Status Lamps: Indicate remote start command, not in auto, warning and shutdown.
 - 4) Exercise switch: Automated exercise function in the DG controller allows the operator to initiate an exercise period and have it automatically completed by the controller. The controller shall start the engine; perform the testing method as specified in the AB Schedules (synch with main supply, dummy resistor load or unloaded); run for a pre-set period; then run down, open the generator breaker, and shut down.
 - 5) Fault Reset switch: Allows the operator to reset the control after a warning or shutdown condition.
 - 6) LED lamp, which indicates that a fault is present on the system.
- b) The following features shall be included in the control panel and not from a local HMI:
- 1) Emergency stop push-button: Provides positive and immediate shutdown of the generator set.
 - 2) Key-type mode selector switch (local/remote/maintenance).

3.6.3.4 Remote Control System Interface (If required in the AB Schedules)

- a) The control system shall cater for all the input/output signals required for a complete system. Remote inputs/outputs may include, but are not limited to the following, **from the Remote Control System (inputs)**:
- 1) Remote Start Command
 - 2) Remote Stop Command
 - 3) Initiate Sync Command
 - 4) Select Generator Breaker for Sync
 - 5) Select Paralleling Breaker for Sync
 - 6) Load Demand (kW)
 - 7) VAR Demand (kVAR)
 - 8) Emergency Mode (disabled engine trips)
- b) The control system shall cater for all the input/output signals required for a complete system. Remote inputs/outputs may include, but are not limited to the following, **to the Remote Control System (outputs)**:
- 1) Control Mode (local/remote/maintenance)
 - 2) Engine Running
 - 3) Load kW (analogue)
 - 4) VARs (analogue)

- 5) Ready to Load
 - 6) Ready to Start
 - 7) Common Alarm
 - 8) Shutdown Alarm
 - 9) Breaker Interface
 - 10) Generator Breaker Open
 - 11) Generator Breaker in Operate Position
 - 12) Generator Breaker Protective Relay Reset
 - 13) Generator Breaker Close Command
 - 14) Generator Breaker Trip Command
 - 15) Generator Breaker Trip Status
 - 16) Paralleling Breaker Open
 - 17) Paralleling Breaker in Operate Position
 - 18) Paralleling Breaker Protective Relay Reset
 - 19) Paralleling Breaker Close Command
 - 20) Generator Voltage
 - 21) Bus Voltage (reference for testing)
 - 22) Paralleling Source Voltage (reference for return after power outage)
- c) If the required input/output signals are not specified by the Employer's Engineer, the control system shall cater for the following:
- 1) 8 × Digital inputs.
 - 2) 2 × Analogue inputs.
 - 3) 16 × Digital outputs.
 - 4) 4 × Analogue outputs.

3.6.3.5 Diesel Generator Control Panel Indications

- a) As a minimum, the following indications are available locally on the DG control panel HMI:
- 1) Control system in remote mode.
 - 2) Control system in local.
 - 3) DG control system healthy.
 - 4) Diesel engine ready to accept load.
 - 5) Main DC supply healthy.
 - 6) Backup DC supply healthy (if required).
 - 7) Generating kVAr (kilovolts-ampere reactive), kW (kilowatt), Volts, Frequency and

Amps are displayed on digital instruments.

- 8) Starter battery charger voltage and current.
- 9) Engine running hours.
- 10) Fuel level.
- 11) Engine temperature.
- 12) Oil pressure.

3.6.3.6 Diesel Generator Annunciator Alarms (if required in the AB Schedules)

a) The following alarms are available on the local DG annunciator:

- 1) Diesel engine start failure.
- 2) Low engine oil pressure.
- 3) Low radiator water level.
- 4) Engine over speed.
- 5) Engine air flaps closed.
- 6) Emergency stop activated.
- 7) Generator field breaker tripped.
- 8) Fuel tank < 5%.
- 9) Fuel tank < 15%.
- 10) Fuel tank > 105%.
- 11) Fuel tank rupture alarm.
- 12) Fire alarm.
- 13) Protection trip.
- 14) High engine temperature.
- 15) Low engine temperature.
- 16) High bearing temperature.
- 17) Stator temperature.
- 18) Under frequency.
- 19) Abnormal voltage.
- 20) Low starter battery voltage.
- 21) Charger fail.
- 22) Auxiliary supply fail.
- 23) Fuel transfer scheme failure.
- 24) Synch Failure.
- 25) DC failure.

26) Moulded Case Circuit-breaker (MCCB) tripped.

b) The following alarms will be repeated for input into the Remote-Control System (i.e DCS):

- 1) Engine protection tripped alarm.
- 2) Engine protection delayed time before trip will occur alarm.
- 3) Engine protection alarm.

3.6.3.7 Safety features

a) The following safety features shall be available:

- 1) A continuously rated, fail-safe engine stop solenoid used to control the fuel injection system.
- 2) An emergency stop push button on the diesel engine.
- 3) An emergency stop push button on the control panel.
- 4) Remote emergency shutdown capability.
- 5) Over speed protection.
- 6) Fully automatic mode with very little human interaction during power restoration after a blackout.
- 7) The DG controller will ensure that an engine will only shut down after running at no load for the engine manufacturer's recommended time period. This no load run is necessary to cool down the turbo chargers properly. However, using the emergency shutdown function will stop the machine immediately. Using the manual key switch function will also override the no load run function.

3.6.3.8 Control System Functionality

- a) Emergency stop: An emergency stop push-button shall be provided both on the engine and on the control panel. These push buttons shall be of the self-latching, twist-to-release type, red in colour, and at least 25 mm in diameter. Directly above each push-button, there shall be a red label indicating the function of the push-button. The button shall open the DG main breaker and shut the diesel engine down by cutting the fuel.
- b) Automatic Voltage Regulator (AVR): The AVR shall control the generator output voltage by three- phase sensing. When operating in either the asynchronous or in the synchronous mode, the AVR' shall operate accordingly.
- c) Control functions: Refer to the Employer's Specification for Works for the required control philosophy.

3.6.3.9 Alarms and Indications

- a) Each alarm shall register and maintain the alarm indication until manually cancelled, even if the signal that initiated the alarm has ceased.
- b) Each alarm shall be displayed in the front of the alarm panel by an indicating lamp, LED, or Liquid Crystal Display (LCD).

- c) A common 'Alarm Reset' push-button shall be provided to restore the control circuit to its original state once the alarm conditions have been noted and rectified.
- d) All alarm lamps or LEDs shall have a Lamp Test facility to test whether they are operational; this facility shall be operated by a single push-button.
- e) Each alarm shall be duplicated at a potential-free changeover contact. Both positions (three wires) shall be wired to outgoing terminals. Archiving/logging of alarms shall be kept.

3.6.3.10 Assemblies, Terminals, Wiring and Cabling

- a) LV Switchgear and control gear assemblies and associated equipment shall be in accordance with [18] 240-56227516 and [20] 32-333.
- b) [17] SANS 10142 shall be used as a minimum for Distribution boards.
- c) External wiring for low voltage control, interlocking, alarm, measuring, and DC circuits shall terminate on numbered wiring terminals that comply with the requirements of [16] SANS 60947-7- 1.
- d) Unless otherwise agreed upon, all terminals shall be marked in accordance with [14] SANS 60034-8. The position of the supplier terminal boxes, if of importance, shall be as specified.
- e) Where heat-generating equipment is present and the internal temperature is likely to exceed 50 °C, heat-resistant insulation (silicon wire) shall be used on stranded conductors. The supplier shall state where such insulation is used.

3.6.4 Auxiliaries

3.6.4.1 Cooling

- a) The engine shall be cooled by a pressurized radiator and shall be entirely self-contained. The radiator shall be filled with anti-freeze.
- b) Unless otherwise specified, fans of engines that are installed in an engine room shall draw air through the room and exhaust it externally. The method of driving the radiator fan (i.e. whether it is driven by electric motor or mechanical coupling to the engine) is listed in Schedule A. Electric motors will only be used for remote radiators and should be avoided where possible.
- c) A heating element operating at either U_{AC} 230 V single-phase, or U_{AC} 400 V three-phase shall be fitted in the engine water jacket to maintain the engine at a temperature suitable for cold starting. It is a requirement that these jacket water heaters can be isolated individually for heating element change out without draining the complete engine coolant capacity.
- d) The element terminals shall be brought out separately, such that both terminals of each heater element are available externally. The element wiring shall be terminated on a separate external terminal strip. The circuit shall be wired independently to ensure that a heater element failure will not affect the DG control system. The power to the heater element shall be thermostatically controlled to adequately regulate the engine

temperature. An alarm shall be issued if the engine temperature drops below the minimum temperature specified by the supplier.

3.6.4.2 Starting

- a) The starting method shall be specified in Schedule A.
- b) For electric motor starter, on initiation of the start command, the engine starter shall make five consecutive start attempts. Depending on the application, the required start philosophy will be as follows and indicated by the Employer's Engineer in Schedule A:
 - 1) Start Initiation 1: maximum duration of 10 s each, with rest periods of not more than 10 s between attempts (Generation Division only).
 - 2) Start Initiation 2: maximum duration of 8 s each, with rest periods of not less than 10 s between attempts.
- c) If the fifth start attempt is unsuccessful, the indication 'Start Failure' (red) shall be activated on the control panel.

3.6.4.3 Batteries

- a) The type of batteries to be used shall be specified in Schedule A.
- b) Batteries shall be rated for the voltage and currents of the starting motors and the control equipment, and for the time requirements of the alarm system specified. Details of the batteries offered shall be provided.
- c) The starting battery discharge capacity at 25 °C shall be such that the full cranking current can be drawn for 30 s, and that the final discharge voltage does not fall below the value as specified in [9] SANS 1632.
- d) During engine operation, the starter battery shall be charged from a charging generator. The battery charger shall take over battery charging when the charging generator fails or if the engine is shutdown.
- e) The battery shall be mounted separately from the vibrating part of the set, preferably in a clean and cool environment.
- f) The battery mounting shall be protected against corrosion, and shall include a spill tray and a transparent cover over the battery.
- g) A removable link system between battery and starters, whereby it is safe to isolate the engine for maintenance, yet have the charger and controller still energized shall be installed. The starter battery mounting shall be as close as possible to the starter motor and shall be arranged in a position permitting easy access for maintenance.

3.6.5 Battery Charger

- a) Equipment shall be provided in the control panel for charging the starter battery from the Employer's Engineer's U_{AC} 230 V or U_{AC} 400 V system.

- b) Battery chargers shall comply with the requirements of [10] SANS 1652, and shall be of the constant voltage, current limited type.
- c) The performance characteristics of battery chargers shall comply with the recommendations of the battery manufacturer.
- d) There shall be a separate charger for each battery/starter system if specified in Schedule A.

3.6.5.1 Fuel System

- a) Each Generator Set shall be equipped with a day tank or base tank as specified in Schedule A and the required accessories such as pumps, valves, and piping to supply the DG Set with fuel, when running at full load for duration as specified in Schedule A.
- b) The fuel system design and installation shall comply with the requirements of the local authority, e.g. fire department, and of the latest OHSAS standards.
- c) Galvanized materials or materials that contain zinc, copper, brass shall not be used in the fuel system for piping, valves, etc.
- d) To filter the input fuel to the DG, a water and fuel separator shall be fitted before the engine supply pump.
- e) The fuel/water separator device shall be installed between the fire shut-off valve and the engine fuel pump.
- f) The water fuel water filter drain shall be connected to an external outlet.
- g) A water level alarm system shall be provided to monitor the water level in the water fuel separator.
- h) The alarm system shall have a 'water in fuel' alarm.

3.6.5.2 Fuel Injection

- a) The engine shall be equipped with a means of priming the fuel system to the injectors following long engine shutdown times.
- b) If the fuel serves as 'injector cooling', the supplier shall provide adequate cooling to the fuel supply system to avoid increases in day tank temperature.
- c) A continuously rated fail-safe engine-stop solenoid shall be provided on the fuel pump supply line.
- d) The main fuel line shall be equipped with a fire-resistant shutdown valve, operated by a fusible link or similar type fire detector that closes off the main fuel supply line and 'spill' return line between the tank and diesel in the event of a fire.

3.6.5.3 Day Fuel Tank (if applicable)

- a) Each engine shall be equipped with its own day fuel tank installed next to the generator.
- b) The supplier shall construct and install the day tank in accordance with [12] SANS 10089 parts 1 to 3.

- c) The capacity of the day fuel tank shall be a minimum of 2 h continuous operation at full load unless specified differently in Schedule A.
- d) The day tank shall be of double wall construction unless specified differently in Schedule A and shall have a leak detection sensor in the interstitial space.
- e) Alarm sensors shall be furnished for high fuel, low fuel, and critical low fuel.
- f) Alarm contacts from these fuel sensors shall be connected to the engine control system for local alarm indication. In addition, single-pole double-throw contacts from each alarm sensor shall be connected to terminal blocks in the engine control panel for the Employer's Engineer's use.
- g) The top of the day tank shall be such as to allow for gravity feed from the bulk storage tank.
- h) The day fuel tank shall have a sloping bottom with a drain valve at the lowest point of the tank. The slope shall be 1:20 towards the drain valve.
- i) The intake to the fuel delivery pipe to the engine shall be located at a level that is equal to a position representing at least 2% of the total tank capacity. A manual shut-off valve (no copper or brass) shall be fitted in this pipe.
- j) The overflow pipe shall be twice the diameter of the filler pipe and shall be so positioned that the overflow can occur only when the tank is 98% full. The overflow pipe shall be connected to the bulk storage tank.
- k) A filler pipe shall be provided and shall preferably pass through the tank top.
- l) A removable hand hole with an inspection cover shall be provided in the top of the day tank, for maintenance purposes. The cover shall have a gasket and be provided with a locking facility.
- m) The capacity of the fuel tank shall be limited to 1 000 l. No farm tank shall be used for fuel storage.
- n) The fuel supply line shall be fitted with a fire valve. For this purpose, a suitably designed fused-link system shall be provided to cut off the fuel to the engine in the event of fire.

3.6.5.4 Diesel Fuel

The fuel injection equipment offered shall use diesel fuel that complies with the requirements of [6] SANS 342.

3.6.5.5 Lubrication

- a) The engine shall be supplied with a force-feed lubrication system rated to supply the circulating lubrication oil to all the bearings, gear trains and other moving parts.
- b) An oil pressure gauge (if required) and an oil pressure sensor and switch shall be so mounted downstream of the oil filter that the engine lubricating oil pressure is readily indicated on the engine or on the control panel (or on both), as specified. The safety range and the danger zones shall be indicated on the gauge.
- c) The oil pressure sensor shall be connected to the control system, to give an alarm and to

stop the engine if low oil pressure occurs.

- d) The oil filter shall have adequate capacity of at least 250 h continuous operation.
- e) Where duplex oil filters are installed, it shall be possible to switch from one filter to the other while the engine is running.
- f) Oil filters shall be readily accessible.
- g) All bearings and continuously rotating moving parts that are not pressure lubricated shall be fitted with sealed ball, roller, or needle bearings.
- h) If so, specified in Schedule A, a lubrication oil make-up tank shall be supplied. The make-up oil shall be gravity fed into the engine sump.
- i) If so, specified in Schedule A, a semi-rotary hand-operated sump drain pump shall be fitted, and so positioned as to facilitate oil drainage during oil change servicing.
- j) If a motor-driven lubricating oil priming pump is provided, this shall be stated in Schedule A. The supplier shall also indicate if this is a prerequisite for engine pre-lubing, and should no oil gallery pressure be successfully achieved, any engines starting shall be aborted.
- k) A label indicating the grade of oil to use the frequency of oil changes and the volume of oil shall be affixed to the engine. The use of multigrade oils is preferred against monograde oils.
- l) Any need for separate oil cooler or auxiliary oil heater or both for cold starting shall be stated in Schedule A together with the power requirements for any auxiliary oil heater.
- m) The crank case breather shall be extended/ routed beyond the radiator system where vapours can be discharged within the hot airflow.

3.6.5.6 Aspiration and Cooling Air Intake

- a) The engine air filter shall be dry type as appropriate for the site conditions.
- b) The air intake shall be so mounted that the intake of dust or other particles is minimized.
- c) The air intake shall be screened to prevent vermin or birds from entering the intake.
- d) If water has entered the intake, it shall be possible to drain the water from a low-lying collection point.
- e) The air filter construction shall be such that the filter element can be readily cleaned or replaced.
- f) If so, specified in Schedule A, a 'differential pressure high' switch shall be provided to indicate a dirty filter element condition.
- g) The air intake shall be positioned such that the intake of exhaust gasses or radiated heat is avoided.

3.6.6 Earthing

3.6.6.1 General



- a) Earthing shall be provided to meet the system protection and safety requirements for the DG Set power circuits. The minimum earth fault current dictates the generator protection settings for correct operation.
- b) The maximum earth fault current and its duration determine the cross-sectional area of the earth conductors to be used.
- c) Independent earthing is required to eliminate electromagnetic disturbances in control circuitry, and to prevent mechanical damage to the shaft and bearings in the set, caused by induced and stray currents.
- d) Provision shall be made by the supplier to enable the earthing of the plant.
- e) The supplier shall provide details of its specific earthing system requirements, philosophy, etc. The system shall be suitable for a movable and transportable unit.

3.6.6.2 Generator Neutral Earthing

- a) Neutral earthing implies interconnection of the generator's neutral and the Employer's Engineer's power system's neutral, which is generally earthed.
- b) Multiple earth connections can cause neutral circulating currents between parallel systems. Care shall be taken to avoid this phenomenon and the consequent unnecessary operation of the protection.
- c) The neutral earthing method employed shall be in accordance with [11] SANS 8528 and will depend on the existing site earthing philosophy, DG mode of operation and level of protection required. The Employer's Engineer shall specify the neutral earthing method in Schedule A.
- d) The neutral connector shall be able to carry the full earth-fault current of the generator.
- e) The supplier shall provide protection of the generator against internal earth faults, and details of such protection shall also be supplied.

3.6.6.3 Earth and Bonding of Components

- a) Each main component of equipment shall be earthed direct to a solid copper earth bar, which shall be connected to the Employer's earth system at a point as specified.
- b) As a rule, the earth continuity conductor shall be of a nominal cross-sectional area at least half that of the largest phase conductor, but not more than 70 mm².
- c) Earth conductors may be bare copper, insulated copper, aluminium or an anti-theft copper/steel compound unless specifically stated in Schedule A. Where aluminium is used as an earth conductor, bimetal connections shall be used between different materials, and these cannot be installed underground.
- d) On batteries and battery chargers, the negative pole shall be earthed to the frame of the set unless specified differently.
- e) The frame of the DG Set shall be flexibly earthed to the earth continuity conductor with due regard to the magnitude and duration of possible local earth faults.
- f) Electrolytic corrosion shall be avoided. A suitable earthing facility shall be provided on the

frame. If so recommended, bypass earthing of insulated bearings shall be carried out by means of an earthed brush, to prevent damage caused by induced shaft currents.

- g) Tanks shall have an earthing facility provided on the tank, for connection of an earth conductor between the tank and the frame of the set.
- h) Junction boxes shall be fitted with an earth terminal. The earthing conductor shall be of suitable cross-sectional area to withstand any earth fault currents.
- i) Junction boxes enclosures shall be rated IP54 as per [15] SANS 60529, unless specified otherwise in Schedule A.

3.6.6.4 Enclosures

- a) Enclosures shall be rated IP65 as per [15] SANS 60529, unless specified otherwise in [15] SANS 60529. Colour shall be as specified in [15] SANS 60529.
- b) Enclosures shall be constructed of minimum 3CR12 material and powder coated to colour as per the Employer's Engineer's requirements.
- c) Enclosure doors shall be positively drawn and closed onto seals by means of pad-lockable lever-operated catches. Cable entry shall be from the bottom using removable gland plates.
- d) Enclosures containing a rectifier and/or inverter shall be fitted with removable filters that prevent the ingress of dust. The airflow to air-cooled components shall be arranged to promote cross ventilation, and such that it cannot be impeded accidentally in any way.
- e) A stud shall be provided for earth connections from inside and outside the enclosure. Where studs are not welded to the plate, flat washers shall be used as the final mating surface in the case of a conductive gland plate. A bolt and nut arrangement may also be used.
- f) Where the plate is coated with non-conductive covering, studs shall be welded to the plate after the coating is removed.
- g) An earth bar shall be provided. The earth bar shall be connected to the earth stud inside the enclosure by the shortest possible path. All earth connections shall follow the shortest path, and no 'pigtailed' (wire coils for neatening purposes) are permissible.
- h) The connection between the earth stud and the earth bar shall be made using a suitability sized conductor and shall be appropriately lugged for the purpose.
- i) Gland plates shall be fabricated from a conductive material and shall be protectively coated against corrosion using a conductive coating, such as cadmium.
- j) The gland plate shall be bolted to the enclosure in at least four places, in such a manner as to ensure galvanic continuity between the plate and the enclosure is ensured.
- k) Doors shall be bonded to the enclosure using earth studs.
- l) Doors > 0,5 m in length shall be bonded in at least two different locations, with 0,5 m spacing between each bond.
- m) Bonds shall be made using braided copper strapping ≥ 10 mm wide and having a width to

3.6.7 Mechanical Build

3.6.7.1 Coupling

- a) The generator and engine may be coupled directly with a flange adapter ring or a bell housing within which a shock absorbing flexible coupling is fitted. The method shall be fully described by the supplier.
- b) In the case of large DG Sets, the generator and engine may be coupled directly.
- c) If the generator is offered with double bearings, it shall be coupled to the engine with a flexible coupling designed to take up any angular misalignment, and to transmit the drive torque smoothly.

3.6.7.2 Base Frames

- a) DG Sets shall be mounted on a simplex frame.
- b) The overall dimensions of the frame shall be provided.
- c) Lifting provisions on the base shall be provided to lift the complete set, including any canopy or enclosure, if fitted. Lifting provisions are to be clearly marked. Lifting eyes not suitable for complete lifting shall be indicated as such.
- d) The maximum overall mass of the DG Set (including oil) and its frame shall be provided. This is required to ensure suitable rated equipment to lift the complete set, without decoupling.
- e) The base shall be so constructed as to allow for an integrated base tank, oil drip tray, and to allow space for draining the engine oil from the sump.

3.6.7.3 Vibration damping

- a) The system shall comply with the requirements of [11] SANS 8528.
- b) Vibration damping mounting details shall be provided.

3.6.7.4 Exhaust System

- a) The exhaust line diameter shall be adequate for the length of the exhaust line.
- b) The exhaust shall have an effective silencer that reduces the noise level to not more than that allowed by local noise regulations.
- c) The exhaust system shall have a low-lying collection point provided with a drain plug, to enable any condensation to be removed.
- d) Exhaust gases shall be released at a location that complies with the local and national regulations and shall not be drawn into the engine or ventilation intake again.
- e) The position of the exhaust shall not hinder operation and maintenance.
- f) The exhaust pipe shall be so arranged as to prevent the ingress of rain and bird nesting.
- g) Emission levels and noise levels shall be as defined in Schedule A. The maximum will be 90 dB.
- h) The exhaust system, with the exception of expansion bellows and flexible joints, shall be

constructed from aluminized steel.

- i) The external (from the building) exhaust system shall be manufactured from (316) stainless steel.
- j) Expansion bellows shall be fabricated from stainless steel and shall be of the type, length and diameter recommended by the supplier.
- k) Leak-tight flexible joints shall allow for expansion and contraction without straining the system.
- l) No welding shall be done on the exhaust system.
- m) Adequate lagging, of non-asbestos material, shall be provided. The type of lagging and the thermal capabilities of the lagging offered shall be provided in Schedule A. As a minimum, the lagging shall be rated 400 °C fiberglass material or other suitable material.
- n) Expansion bellows shall not be lagged. Flexible joints shall be lagged.
- o) The piping outside the Plant room shall not be lagged. Non-lagged piping shall be corrosion protected with a heat-resistant paint.
- p) Exhaust lagging shall be protected by means of metal cladding/cowling if specified in Schedule A.
- q) Safety guards to prevent accidental contact shall be provided over all exposed exhaust pipes and bellows.
- r) Suitable flexibility shall be built into the system to isolate the exhaust system from the structure, and to prevent any stresses on the engine flanges. Relative movement of the engine and surrounding structure shall be considered.
- s) Hangers, supports and guides shall be designed to allow for expansion and contraction, and to allow necessary access to the set.
- t) All metal and surface preparation, painting and coating processes shall comply with the requirements of [19].
- u) Before lagging, all silencers, fittings, etc. shall be painted with heat-resistant, aluminium/zinc- based, high-temperature paints.
- v) Exhaust outlets shall either be fitted with a weight-operated rain flap; or, if exiting in a horizontal direction, fitted with a 'bird screen' and appropriately cut at an angle that does not allow rain water to enter the opening.
- w) Exhaust cowling/cladding shall be manufactured from (316) stainless steel sheet as a minimum.
- x) Rubber hoses and belts shall not be painted.

3.6.7.5 Fire Protection

- a) A fire risk analysis shall be performed to determine suitability to the required solution.
- b) Fire protection and detection shall be provided by others if required.

3.6.7.6 Outdoor Canopy (if required)

- a) Refer to Schedule A for whether an outdoor canopy is required. If required, the canopy will comply with the following:
 - 1) The canopy shall be sized for the required generator.
 - 2) The canopy shall be constructed from minimum 3CR12 and epoxy powder coated for a coastal environment.

3.6.7.7 Acoustic Canopy (if required)

Under special conditions, an indoor acoustic canopy may be required to reduce the acoustic noise level. The requirement will be specified in Schedule A.

3.6.7.8 Control Panel

- a) The control panel shall:
 - 1) be vermin-proof.
 - 2) have 20% of component mounting space and wire ways available for future additions.
 - 3) include 'closed cell' neoprene seals throughout to ensure that foreign objects, such as dust and moisture, do not ingress into the enclosure.
 - 4) have an easy means of access to the underside of the gland plates from above floor level.
 - 5) have removable, cadmium-plated, hot-dip galvanized or white painted, steel equipment- mounting panels or chassis, of thickness at least 2 mm.
 - 6) include suitable rigging facilities (eyebolts, lifting brackets, etc.) if required. There shall be no protrusions beyond the bounds of the cubicles.
 - 7) have sufficiently large doors, stiffened if necessary, to permit easy and complete access to the interior.
- b) In addition, the doors shall have:
 - 1) one pad-lockable locking mechanism on doors of height < 600 mm.
 - 2) two pad-lockable locking mechanisms on doors of height in the range 600 mm to 1 200 mm.
 - 3) three lockable mechanisms in doors of height > 1 200 mm, one of which is pad lockable.
 - 4) keepers, if necessary, to keep the door open
 - 5) corrosion-resistant hinges and handles; and
 - 6) removable, undrilled, cadmium-plated or hot-dip galvanized steel gland plates of thickness at least 2 mm.
- c) Individual component labelling shall be placed on the backing plate.
- d) The engine control panel can be mounted to the base frame if additional anti-vibration bolts are used, all components are securely fixed and suitably rated for the vibrations.
- e) Alternatively, the control panel can be mounted separately using 'anti-vibration' fix on the concrete floor to ensure that engine vibrations do not cause unnecessary vibration of the

components mounted within the engine.

- f) All relays shall be adequately secured to prevent the relay base from falling out during vibrations.
- g) The wiring between the control panel and the engine-mounted devices shall be resistant to temperature.
- h) Components shall be mounted in the compartments on the equipment mounting plates or chassis, using bolts screwed into tapped holes, or hank nuts that engage at least three full threads.
- i) A DIN mounting rail shall be fixed to the mounting plate or chassis in a similar manner.
- j) Self-tapping screws or bolts with loose nuts shall not be used.
- k) Components shall be spaced at least 10 mm apart when components are dissimilar or intended for flush mounting on front doors and covers.
- l) Equipment manufactured for surface mounting shall not be modified for flush mounting and shall be labelled exactly in accordance with the drawing or the wiring diagram.
- m) Fuse bases shall be labelled with the rating of the fuse link that should be fitted into them.
- n) Control transformers shall:
 - 1) Be double-wound isolating transformers with an earth screen between the primary and secondary windings; rated Class 1; and not exceed the burden.
 - 2) Have one leg of the secondary winding earthed.
 - 3) Include at least 25% spare output capacity.
- o) Wiring in the assemblies shall be:
 - 1) Run in covered wire duct that is filled to not more than 80% of its capacity.
 - 2) Protected against chafing, with grommets, where it passes through the panel work.
 - 3) Loomed with spiral wrap or alternative protection, and arranged for minimal twisting rather than a bending action where it crosses door hinges and other areas that can move relative to one another.
 - 4) Thermoplastic-insulated or thermosetting-insulated, stranded copper wire. Solid conductors shall not be used.
 - 5) Of cross-sectional area at least 1,5 mm², except for current transformer circuits, where it shall be at least 2,5 mm² and shall be 600 V/1 000 V grade in accordance with [8] SANS 1507.
 - 6) Identified at each end with an indelibly marked, interlocking, slip-on identification ferrule. The number on the ferrule shall be shown on the wiring diagram; adhesive wrap-on type ferrules shall not be used.
 - 7) Terminated at each end with pre-insulated crimp lugs. Lugs shall be crimped on with ratchet type crimping tools that do not release until the crimp is complete.
 - 8) Colour-coded in accordance with [18] 240-56227516.
 - 9) Free from joints or splices.

- p) All terminals shall, as far as possible, be at the front of the control panel, and shall be accessible without it being necessary to disturb wiring or remove components.
- q) All metalwork, including the cabinet, shall be electrically bonded to the earth connection with a conductor of suitable cross-section.

3.7 Marking, Labelling and Packaging

3.7.1 General

A metal file holder or box shall be provided and attached at a suitable location for the purpose of holding relevant documentation and drawings.

3.7.2 Marking

- a) All water pipes for external cooling circuits shall be clearly and permanently marked at all connection points to indicate the direction of flow.
- b) All drain plugs shall be clearly marked with an identifying colour in accordance with [13] SANS 10140 parts 1 to 3.
- c) Fuel pipes and taps to be clearly marked and labelled.
- d) Battery and DC circuit terminals shall be clearly marked to indicate their polarity.
- e) All timers shall be marked or labelled to indicate their time control range.
- f) Earth connections shall be labelled with a standard earth symbol in black on a yellow background.

3.7.3 Labelling

3.7.3.1 Labels

- a) Labels shall be in English.
- b) Labels shall be indelibly and permanently marked and shall be securely attached to the equipment.
- c) A label indicating the grade of oil shall be attached to the diesel engine.
- d) All printed-circuit cards shall be clearly identified.
- e) All instruments shall be clearly labelled to indicate their function, and all alarm indicators shall be clearly labelled to indicate the alarm they represent.
- f) Statutory labels required to be attached to building doors, etc. shall be provided and fitted when applicable.
- g) Labels that have red letters on a white background, the lettering being of height at least 10 mm, shall be affixed to all places where danger can exist owing to automatic start-up. The text on these labels shall be in accordance with 3:

Table 3: Danger label

<p>DANGER</p> <p>THIS MACHINE SHALL START WITHOUT NOTICE. BEFORE WORKING ON THE MACHINE, LOCK THE CONTROL SWITCH ON THE CONTROL PANEL IN THE OFF POSITION</p>

- h) A label shall be attached adjacent to each terminal to indicate its function and designation in accordance with the relevant circuit diagram.
- i) A graphic diagram with an electric flash in accordance with type designation WW7 of [7] SANS 1186, and a label indicating the voltage shall be placed near all mains terminals.
- j) Labels may be engraved on sandwich plastic material that is suitable for tropical outdoor use.
- k) Warning and danger labels shall be in red on a white background.
- l) Information and instruction labels shall be in black on a white background.
- m) Devices fitted to the set shall be labelled in accordance with the relevant circuit diagram.
- n) Components shall not be labelled on the component, but on the chassis or printed circuit board adjacent to the component.
- o) Electronic modules shall be labelled to identify them, and the rear connectors shall be keyed to prevent incorrect positioning.

3.7.3.2 Rating Plates

- a) All major items of plant shall be provided with corrosion-resistant rating plates that comply with the requirements of the South African National Standards (SANS).
- b) The following details shall be clearly, legibly, and indelibly marked on the plates:
 - 1) manufacturer's name
 - 2) manufacturer's type number
 - 3) manufacturer's serial number
 - 4) year of manufacture
 - 5) rated engine speed, power, operating altitude
 - 6) voltage, power factor, frequency, etc.
 - 7) short-time withstand current, in kilo-amperes (kA), for the maximum time, in seconds
 - 8) performance class
 - 9) load acceptance
 - 10) type of fuel used
- c) Rating plates shall be permanently fixed in a prominent position on the equipment.

3.7.4 LOAD BANK (DUMMY LOAD)

- a) A correctly sized Load Bank to be supplied to enable periodic testing, including for built-in capability of feeding the Employer's Local Grid through the synchroniser controller and motorised autochangeover during routine tests, if the load present on the local grid is sufficient for the test.
- b) If the load present is insufficient for test requirements the option to use the Load BANK in combination with grid load shall be available, in addition to the option of LOAD BANK only.

3.7.5 Packaging and Shipping

- c) The system shall be suitable packed to prevent damage to the system or any components during transportation to site, and to allow for outdoor storage on site before installation.
- d) The DG System may be shipped as a unit or dismantled (shipped as a unit as far as practically possible).

4. Tests

4.1 Responsibility for Testing

- a) The supplier shall be responsible for all tests.
- b) Test shall be performed and certified in accordance with [11] SANS 8528-6 and this section of the standard.
- c) As a minimum, the International Organization for Standardization (ISO) standard functional tests (as specified in [11] SANS 8528-6) and the tests specified in sections 4.1.48-4.1.51 shall be performed.
- d) Additional ISO standard acceptance tests to be performed shall be specified in Schedule A.

4.2 Type Tests

- a) All test certificates for all the Genset shall be provided from the OEM component manufacturers. The component certificates shall be submitted with the tender documents.
- b) Type tests shall include as a minimum:
 - Measurement of Winding Resistance
 - Voltage Ratio & Vector Relationship Test
 - Impedance Voltage & Short-Circuit Test
 - No-Load Loss & Current Test
 - Separate-Source Voltage Withstand Test
 - Induced Overvoltage Withstand Test
 - Lightning Impulse Test

- Temperature Rise Test

c) The following Compliance Standards must be met:

- IEC 60034-22 (Alternator Performance)
- IEC 60034-1 (Mechanical & Electrical Performance)
- European Non-Road Mobile Machinery Directive (NRMM) 2016/1628/CE or EU Stage V minimum

4.3 Insulation Resistance Testing

- a) An insulation resistance test shall be applied to all circuits that do not contain components such as semiconductor devices, electronic modules and printed-circuit cards.
- b) Printed-circuit cards shall be removed from the connectors prior to testing of circuits.
- c) This test shall be performed in an atmosphere where the relative humidity is not higher than 85%, and shall consist of the following:
- 1) a test voltage of 2 kV (rms) applied for 1 min for all AC circuits below 1 000 V, between the conductors and any earthed components.
 - 2) a DC test voltage of 500 V applied for 2 min between two separate circuits, using a 500 V resistance tester. The resistance recorded shall exceed 50 M Ω .
 - 3) a test voltage as in (b) above, but between all circuits connected together and the frame.
 - 4) a test voltage of 1 kV (rms) applied for 1 min to all DC circuits.

4.4 Factory Acceptance Tests

- a) As a minimum, the following Factory Acceptance Tests (FATs) shall be performed:
- 1) A full functional test of all control and operating systems.
 - 2) A full load test, at the rated kilovolt-ampere (kVA) of the generator, for a period of at least 8 hours.
- b) The full load test should be followed immediately by any overload capacity test as specified. During this test, the following shall be recorded at 10 min intervals:
- 1) engine temperature
 - 2) engine oil pressure
 - 3) generator voltage
 - 4) generator frequency
 - 5) generator current
- c) The DG shall be capable of performing a single load step equal \geq 50% of the continuous kilowatt (kW) rating of the machine while remaining within operating limits.
- d) The DG shall be capable of performing a single load step equal to 110% of the most severe single step load in the plant design profile. The DG shall accept the load without voltage collapse or engine stalling and recover to normal operating speed. The supplier shall

document the voltage and frequency deviation observed.

- e) The supplier shall provide the Employer's Engineer with copies of the following:
 - 1) The engine manufacturer's test results, clearly indicating the specified performance.
 - 2) The generator manufacturer's test results, clearly indicating the specified performance.
 - 3) A pressure test of the air receiver of the compressed-air starter system.
 - 4) A pressure and functional test of the air valves included in the compressed-air starter system.
- f) The supplier shall perform a simulated function test of the control panel.
- g) Test results shall indicate that the performance at the specified site altitude meets the requirements of [3] ISO 3046.

4.5 Site Acceptance Tests

- a) On completion of the installation, the following Site Acceptance Tests (SATs) shall be performed:
 - 1) A full Functional test and Acceptance test of all control and operating conditions.
 - 2) A load test utilizing the available site load and under the load parameters given, for a period of at least 1 hour (if practically possible).
- b) During the load test, the following shall be recorded at 10 min intervals:
 - 1) engine temperature
 - 2) engine oil pressure
 - 3) generator voltage
 - 4) generator frequency
 - 5) generator current
- c) The load test shall be continued until it is established that the engine temperature is stable for at least 20 min.
- d) The equipment shall perform in accordance with the requirements as specified; and the noise produced by the engine/generator set shall comply with the noise levels as specified.
- e) The following tests shall then be performed:
 - 1) Battery discharge test.
 - 2) Battery charger test.

5. Authorization

This document has been seen and accepted by:

Name and surname	Designation

Annex A – A/B Technical Schedules

NOTE: Schedule A: User requirements - Indicates typical requirements for Generation applications where S >1MVA. Change User requirement as per application.

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.0	Qualification				
AB.0.1	Local Agent Representation required	Yes / No	Yes (Provide Details)		
AB.0.2	Number of Years local representative exists in South Africa	Years	Yes		
AB.0.3	Supply Reference list with installations (Projects), designs and MVA size (not less than 1000KVA) duration, location, contract persons	Yes / No	Yes		
AB.0.4	Compliance with SANS (ISO) 9001:2008 required	Yes/No	Yes		
AB.0.5	The Diesel Generators are to build in accordance with SANS 8528-All Parts	Yes/No	Yes		
AB.1	The Works				
AB.1.1	Supplier				
	Generator Set Output Characteristics (No transformer Required to achieve the output Voltage)	kVA/V	1000kVA prime		
AB.1.1	Number of Diesel Generator Sets required		1		
AB.1.2	Name of Diesel Generator Set Manufacturer (Local/ Foreign)				
AB.1.3	Factory Test	Yes / No	Yes		
AB.1.4	Install and Erect	Yes / No	Yes		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.1.5	Site test and Commission	Yes / No	Yes		
AB.1.6	Install Fire Protection System	Yes / No	No		
AB.1.6.1	Perform Fire Risk Analysis	Yes / No	Yes		
AB.1.7	Type Of Fire Protection System				
AB.1.8	Fire Protection Trigger system				
AB.1.9	Diesel Generator Set Components and Services required		Yes- 5 year and 10000 hrs		
AB.1.9.1	Local Control Cubicle	Yes/No	Yes (One for each Diesel Generator)		
AB1.9.1.1	Local Control Panel contains AVR	Yes/No	Yes		
AB1.9.1.2	Local Control Panel contains Governor Controller	Yes/No	Yes		
AB1.9.1.3	Local Control Panel contains Interlocking Logic, Alarming, Tripping and Annunciation	Yes/No	Yes		
AB1.9.1.4	Controller Battery Chargers and Battery	Yes/No	Yes		
AB1.9.1.5	Synchronizing Equipment	Yes/No	Yes		
AB1.9.1.6	Interfaces with Remote Control System	Yes/No	Yes		
AB.1.9.2	Control wiring between Control Cubicle and Diesel Generator	Yes/No	Yes		
AB.1.9.3	Diesel Generator Engine	Yes/No	Yes		
AB.1.9.4	Generator	Yes/No	Yes		
AB.1.9.5	Diesel Bulk Tank	Yes/No	No		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.1.9.6	Diesel Day Tank	Yes/No	Yes-Integrated Base		
AB.1.9.6.1	Maximum height from the finished floor to the top of Day Tank	m			
AB.1.9.7	Interlocking and Control cabling between Diesel Generator Control Panels	Yes/No	No		
AB.1.9.8	Control cabling between Diesel Generators and relevant Switchgear	Yes/No	No		
AB.1.9.9	First Fuel fill				
AB.1.9.9.1	Supply First Fuel Fill for Commissioning and Testing Purposes	Yes / No	Yes		
AB.1.9.9.2	First Fill Amount	liters	Full Tank		
AB.2	Contractor Facilities				
AB.2.1	Contractor to provide own cranes for off-loading equipment	Yes / No	Yes		
AB.2.2	Contractor to provide own jacks & other tools for off-loading	Yes / No	Yes		
AB.2.3	Height of Lift required	m			
AB.2.2	Contractor to provide own lifting equipment	Yes / No	Yes		
AB.3	Site Conditions:				
AB.3.1	Site Criteria	Marine/ Land Use			

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
		Coastal/ Land Use Inland			
AB.3.2	Altitude above sea level	m			
AB.3.3	Ambient air temperatures:				
AB.3.3.1	Average Ambient Temperature	°C	25		
AB.3.3.2	Maximum Temperature	°C	42		
AB.3.3.3	Minimum Temperature	°C	0		
AB.3.4	External Vibration source		Normal		
AB.3.5	Radiation	Yes/No			
AB.3.6	Chemical Pollution	Yes/No			
AB.3.7	Dust Pollution		High		
AB.3.8	External Cooling Water Average Temperature				
AB.3.9	Humidity	%	30% to 80%		
AB.4	Generator Set Generic Requirements				
AB.4.1	Designed Operating Life	Years	20		
AB.4.2	Warranty of parts	Years	Minimum 5		
AB.4.3	Application	Continuous Operation at Constant Load/ Continuous Operation at Varying Load/	Continuous Operation at Varying Load		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
		Limited Time Operation at Constant Load/ Limited Time Operation at Varying Load			
AB.4.4	Operation	Parallel/Single/ Parallel with Utility supply	Parallel/Parallel with Utility		
AB.4.5	Generator Set Class	G1/ G2/ G3/ G4	G3		
AB.4.6	Maximum (Starting) load increment which may be applied with the voltage and frequency maintained within the limits specified (load acceptance)	kW	As per ISO 8528- 5:2022 for Class G3		
AB.4.7	Cold Start Time (To rated Speed)	s			
AB.4.8	Time from Rated speed to acceptance of Full Load	s			
AB.4.9	Time that the Generator Set can run at No Load	s			
AB.4.10	Start Up Classification	Long Break/ Short Break/ No Break			
AB.4.11	Installation Requirements	Inside (Indoors) Installation/ Outside Installation with Protection/ Open Air	Outside Installation with Protection- enclosure type		

		Installation			
	Sound attenuation	dB	65dB at 1m		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.4.12	Installation Configuration	Fixed/ Transportable/ Mobile	Transportable		
AB.4.13	Generating Set Configurations	A: without base frame/ B: with base frame/ C: with base frame, integrally mounted control gear, day tank, and auxiliaries/ D: configuration as given in C with enclosure/ E: configuration as given in C having an integral set of wheels or mounted on a trailer	C		
AB.4.14	Mounting Type	Ridged/ Fully Resilient Semi-Resilient/Resilient Foundation			
AB.4.15	Coupling Arrangement	rigid/ torsionally			

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
		rigid/ flexible/ torsionally flexible or clutch			
AB.4.16	Maximum acoustic noise level in the Generator Room at specified distance	dBa	65		
		m	1		
AB.4.17	Generator set, terminal box and control panel	IP Rating	65		
AB.5	Generator-Set Routine Testing (Routine Load testing to ensure reliability of the Generator Set)				
AB.5.1	Required Generator-Set Test Frequency	Times per month	Per OEM requirement		
AB.5.2	Testing Method	Synch with Main Supply/ Dummy resistor/ Load Unloaded	Synchronized with Main Supply (Automated)		Specify whether the testing method must be performed automatically
AB.5.3	Minimum Loading during routine Testing (if applicable). Preferred 70-80% load with bi-annually running at 100 and 110% loading	kW			
AB.5.4	Interval between major services				
AB.5.5	Interval between minor services				

AB.5.5.1	Oil change intervals of engine sump	Monthly/ hours run time, / or oil condition monitoring bases.	Per OEM requirement		
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Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.6	Generator-Set Engine Details				
AB.6.1	Manufacturer of Engine and Turbo Charger / Supercharger		Deutz/Cummins/Volvo Penta/Perkins/Caterpillar/Scania/Baudouin		
AB.6.2	Type				
AB.6.3	Rated Speed	rpm			
AB.6.4	Idle Speed	rpm			
AB.6.5	Over Speed withstand capability	%	125		
AB.6.6	Critical Speeds	rpm	Shall not be above or below 25% of rated speed		
AB.6.7	Speed at point of stalling	rpm			
AB.6.8	Prime Mover Type	Compression-Ignition Engine/ Spark-Ignition Engine	Compression Ignition		
AB.6.9	Continuous Power Output (COP)	kW			
AB.6.10	Prime Power (PRP)	kW			
AB.6.11	Limited-Time Running Power (LTP)	kW			
AB.6.12	Emergency Standby Power (ESP)	kW			

AB.6.12	Overload capability (Two hours in any 24-hour period)	%	10		
AB.6.13	Additional governing power reserve*	%	10		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.6.14	Minimum Running Load of rated without adverse effect on the Prime Mover	%	30		
AB.6.15	Engine Power Output at Sea Level				
AB.6.16	Engine Output at maximum Engine capability				
AB.6.17	Maximum (Starting) permissible frequency deviation during sudden application of Load	%	According to SANS 8528-5		
		kW			
AB.6.18	Aspiration	Super Charged/ Turbo Charged/ Naturally Aspirated			
AB.6.19	Number and Arrangement of Cylinders				
AB.6.20	Bore and Stroke	Mm			
AB.6.21	Piston Displacement	Cubic meters			
AB.6.22	Compression Ratio				
AB.6.23	Piston speed at rated rpm	m/s			
AB.6.24	Lubricating oil consumption at rated output	l/kW			
AB.6.25	Delay between application of loads	s			

AB.6.26	Diesel Generator and auxiliary systems enclosures type	IP Rating	65		
AB.6.27	Diesel Generator and auxiliary systems enclosures colour	Colour			

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
*This additional percentage governing power is not the same as the overload power.					
AB.7	Generator-Set Engine Lubrication				
AB.7.1	Engine Lube Oil Storage capacity	l			
AB.7.2	Oil Flow Required to maintain the Recommended temperature difference between the engine inlet and outlet	l/s			
AB.7.3	Maximum Lube Oil temperature at Full Load Capacity	°C			
AB.7.4	Lube Oil sump Running Capacity	l			
AB.7.5	SAE rating and Type of Lube Oil				
AB.7.6	Number of Oil Filters				
AB.7.7	Oil Filter Type				
AB.7.8	Location of Oil Pressure sensor				
AB.7.9	Oil Temperature System Required	Yes/No	Yes		
AB.7.9.1	Sump breather pipe to be vented beyond radiator/outside of building to avoid vapours fouling up radiator	Yes/No	Yes		
AB.7.10	Lube Oil Pump				
AB.7.10.1	Engine Driven Lube Oil Pump required	Yes/No	Yes		
AB.7.10.2	Lube Oil Pump manufacturer				

AB.7.10.3	Lube Oil Pump Type				
AB.7.10.4	Lube Oil Pump Capacity	l			

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.7.10.5	Electrical Standby Lube Oil Pump required	Yes/No	Yes		
AB.7.10.6	Standby Lube Oil Pump manufacturer				
AB.7.10.7	Standby Lube Oil Pump Type				
AB.7.10.8	Standby Lube Oil Pump Capacity	l			
AB.7.10.9	Motor Size	kW, rpm, Voltage			
AB.7.11	Lube Oil Cooler				
AB.7.11.1	Manufacturer				
AB.7.11.2	Heat Exchanger Type				
AB.7.11.3	Heat Exchanger Class				
AB.7.11.4	Duty at Rated Load	J/hour			
AB.7.11.5	Effective Heat transfer area	meters square			
AB.7.11.6	Temperature Into the Heat exchanger (Normal)	°C			
AB.7.11.7	Temperature out of the Heat exchanger (Normal)	°C			
AB.7.11.8	Temperature Into the Heat exchanger (Maximum)	°C			
AB.7.11.9	Temperature out of the Heat exchanger (Maximum)	°C			
AB.7.11.10	Design Pressure Drop	Pa			
AB.7.11.11	Design Velocity	m/s			

AB.7.11.12	Design Pressure Drop	Pa			
AB.7.11.13	Design Temperature	°C			
AB.7.11.14	Fouling Factor				

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.8	Closed Cooling System				
AB.8.0	Cooling system designed for an ambient temperature of	°C			
AB.8.1	Engine driven Cooling pump Required	Yes/No	Yes		
AB.8.2	Cooling Pump Manufacturer				
AB.8.3	Cooling Pump Type				
AB.8.4	Cooling Pump Capacity	l/s			
AB.8.5	Standby Electric Motor Driven Pump required	Yes/No	No		
AB.8.6	Cooling Pump Type				
AB.8.7	Cooling Pump Capacity	l/s			
AB.8.8	Cooling Pump Motor size	kW, Rpm, V			
AB.8.9	Flow	l/s			
AB.8.10	Maximum water inlet temperature at full rated load	°C			
AB.8.11	Pressure drop through engine heaters and jackets	Pa			
AB.8.11.1	Coolant Temperature sensor required	Yes/No (Position)	Yes		
AB.8.12	Radiator				
AB.8.12.1	Radiator Manufacturer (Radiator must be OEM)	Yes/No	Yes		

AB.8.12.2	Radiator Mounting	Horizontal / Vertical	Vertical		
AB.8.12.3	Size (KW heat rejection)				

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.8.12.4	Capacity	l/s			
AB.8.12.5	Cooling Fan drive (Engine driven is the preferred)	Engine/ Motor Driven	Engine		
AB.8.12.6	Fan(s) Make				
AB.8.12.7	Radiator(s) / Cooling Tower Fluid Type		Anti-Freeze		
AB.8.12.8	Radiator(s) / Cooling Tower Fluid Flow Rate	l/s			
AB.8.12.9	Radiator(s) / Cooling Tower Fluid temperature In Normal	°C			
AB.8.12.10	Radiator(s) / Cooling Tower Fluid temperature Out Normal	°C			
AB.8.12.11	Radiator(s) / Cooling Tower Fluid temperature In Maximum	°C			
AB.8.12.12	Radiator(s) / Cooling Tower Fluid temperature Out Maximum	°C			
AB.8.12.13	Radiator(s) / Cooling Tower Design Pressure Drop	Pa			
AB.8.12.14	Radiator(s) / Cooling Tower Design Temperature	°C			
AB.8.12.15	Fouling Factor				
AB.8.13	Coolant Pre-Heating System				

AB.8.13.1	Supply Coolant pre-heating System	Yes/No	Yes		
AB.8.13.2	Coolant Pre-Heating Type		Thermo-Static Heater		
AB.8.13.3	Coolant Pre-Heating control temperature	°C (switch on) / °C			

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
		(switch off)			
AB.8.13.4	Pre-Heating System Power Requirements	kW			
AB.8.13.5	Pre-Heating System Voltage	V	400V 3-phase or 230V 1-phase		
AB.8.13.6	Contractor to specify ideal pre-heating temperature.	Yes/No	Yes		
AB.9	Engine Air Intake				
AB.9.1	Airflow required per engine ventilation	cubic- meters/second			
AB.9.2	Air Filter Make and Model				
AB.9.3	Air Filter Type				
AB.9.4	Air Filter Size	(LxDxW)m			
AB.9.5	Silencer Make and Model				
AB.9.6	Maximum allowable pressure drop in intake piping				
AB.9.7	"Blocked" Filter indicator to be fitted	Yes/No	Yes		
AB.10	Exhaust System				

AB.10.1	Maximum Allowable Exhaust Pressure Drop	Pa			
AB.10.2	Lagging offered				
AB.10.3	Thermal Properties of Lagging Material offered				
AB.10.4	Silencer Make and Model				

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.10.5	Silencer pressure drop at Rated Flow	Pa			
AB.10.6	Silencer Manufacturer				
AB.10.7	Silencer type & model				
AB.10.8	Silencer weight				
AB.10.9	Silencer noise reduction	dBa			
AB.10.10	Silencer and Exhaust piping material				
AB.10.11	Exhaust outlet flaps/screening to be detailed				
AB.10.12	Exhaust drains to be provided				
AB.11	Fuel System				
AB.11.1	Fuel Pump Drive	Engine/ Electric Motor	Engine		
AB.11.2	Fuel Pump Manufacturer				
AB.11.3	Fuel Pump Type and Model				
AB.11.4	Fuel Pump Capacity	l/s			
AB.11.5	Fuel Pump Motor size	kW, rpm, V			
AB.11.6	Standby Electrical Fuel Pump required	Yes/No	Yes		
AB.11.7	Standby Electrical Fuel Pump Manufacturer				

AB.11.8	Standby Electrical Fuel Pump Type and Model				
AB.11.9	Standby Electrical Fuel Pump Capacity				
AB.11.10	Standby Fuel Pump Motor Size	kW, rpm, V			

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.11.11	Engine Fuel Injection System Manufacturer				
AB.11.12	Engine Fuel Injection System Fuel Filters	Simplex/Duplex	Duplex		
AB.11.13	Fail Safe engine fuel cut-off solenoid required	Yes/No	Yes		
AB.11.14	Diesel Fuel Consumption				
AB.11.14.1	Fuel Consumption at Rated Load	l/kWh @ temperature			
AB.11.14.2	Fuel Consumption at ¾Load	l/kWh @ temperature			
AB.11.14.3	Fuel Consumption at ½ Load	l/kWh @ temperature			
AB.11.14.4	Fuel Consumption at ⅓ Load	l/kWh @ temperature			
AB.11.15	Fuel Storage				
AB.11.15.1	Number of Day Tanks Required Per Engine	number	1		
AB.11.15.2	Day Tank capacity for continuous operation for a single generator set at full load	hours	2		
AB.11.15.3	Percentage Fuel Spare capacity required	%	10		

AB.11.15.4	Day Tank Volume	Litres			
AB.11.15.5	Day Tank Dimensions	L x W x H			
AB.11.15.6	Double Walled Day Tank Required	Yes/No	Yes		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.12	Generator				
AB.12.1	Generator Type	Asynchronous/ Synchronous	Synchronous		
AB.12.2	Generator class		S1		
AB.12.3	Manufacturer		Marelli Motori		
AB.12.4	Type and Model				
AB.12.5	Number of Phases	Single or Three			
AB.12.6	Continuous Power Rating	kW			
AB.12.7	Overload capability (Two hours in any 24 hour period)	%	10		
AB.12.8	Power Factor	PF	0.8 to 1		
AB.12.9	Generator Amperes	A			
AB.12.10	Generator Terminal Voltage phase to phase at No Load	V			
AB.12.11	Generator Terminal Voltage at Full Load	V	400V		
AB.12.12	Steady State Voltage Droop (0-110% of Full Load)	%			
AB.12.13	Maximum (Starting) permissible voltage drop during sudden application of Load	%	According to SANS 8528-5		
AB.12.14		kW			

AB.12.15	Basic Impulse withstand (BIL)	V	95000		
AB.12.16	Power Frequency withstand Voltage	kV rms	28		
AB.12.17	Generator Insulation Class		F or H		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.12.18	Generator Rotor Rated Speed	rpm			
AB.12.19.1	Generator Stator Temperature Rise	K	Limited to class 130 (B)		
AB.12.19.2	Rotor Insulation Class		F		
AB.12.19.3	Rotor Temperature Rise above Ambient	K	105		
AB.12.20	Generator Efficiency				
AB.12.20.1	Generator Efficiency at Full Load and 0.8PF	%	Min 95.3%		
AB.12.20.2	Generator Efficiency at ¾ Load and 0.8PF	%			
AB.12.20.3	Generator Efficiency at ½ Load and 0.8PF	%	Min 95.6%		
AB.12.20.4	Generator Efficiency at Full Load and 0.9PF	%			
AB.12.20.5	Generator Efficiency at ¾ Load and 0.9PF	%			
AB.12.20.6	Generator Efficiency at ½ Load and 0.9PF	%			
AB.12.20.7	Generator Space heater (Supply Voltage 400V or 230V)	Yes/No	Yes		
AB.12.21	Reactance Values expressed on rated kVA base				
AB.12.21.1	Direct Axis, synchronous, Xd				
AB.12.21.2	Quadrature axis synchronous, Xq				
AB.12.21.3	Direct Axis transient, X'd				

AB.12.21.4	Direct Access Sub transient Axed			
AB.12.21.5	Negative sequence, X2			
AB.12.21.6	Zero Sequence, X0			

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.12.21.7	Armature reactance at 75 °C				
AB.12.21.8	X/R ratio				
AB.12.21.9	Generator Zero sequence capacitance				
AB.12.21.10	Generator Short Circuit Ratio				
AB.12.21.11	Generator cooling		Air Self ventilated		
AB.12.22					
AB.12.22.1	Direct axis transient, open circuit, T'do	s			
AB.12.22.2	Direct axis transient, short circuit, T'd	s			
AB.12.22.3	Direct axis Sub transient, short circuit, T''d	s			
AB.12.22.4	Synchronization coefficient	kW/T			
AB.12.22.5	Time required for the Generator Output voltage to return to normal following a three-phase short circuit, cleared within 100ms with the Generator at rated speed and full load prior to the fault	s			
AB.12.22.6	The Generator no-load line-line voltage output waveform deviation from an ideal sine wave at rated voltage and frequency	%			
AB.12.23	Rated Short circuit withstand current (10s)				
AB.12.24	Maximum permissible asymmetric load at 0.8 p.f	%			

AB.13	Regulation and quality of supply				
AB.13.1	Base Frequency	Hz	50		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.13.2	Continuous frequency operating range	Hz	48.5 to 51.5		
AB.13.3	Frequency deviation not more than 10 minute per incident	Hz	48 to 52		
AB.13.4	Frequency deviation not more than 1 minute per incident	Hz	47.5 to 52.5		
AB.13.5	Total Harmonic Distortion (THD) of HV side Voltage and % even harmonics	% / %	5/1		
AB.13.6	HV side Voltage symmetrical three phase supply voltages (negative and zero phase sequence voltages less than)	%	2		
AB.13.7	Continuous Overflux rating	%	110% continuously		
AB.13.8	Load type		Impact Type loading		
AB.13.9	Adjustment Range on terminal voltage	%	±2.5		
AB.13.10	adjustment range of terminal frequency	%	±1.5		
AB.13.11	Voltage Output Waveform				
AB.13.11.1	Waveform deviation factor limit	%	<10		
AB.13.11.2	Total Harmonic Distortion relative to the fundamental	%	<5		
AB.13.11.3	Percentage of any one harmonic relative to the fundamental	%	<3		

AB.13.12	Alternator Bearings		Cartridge assemble type		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.14	Generator Protection				
AB.14.1	Electrical Protection				
AB.14.1.1	Supply Differential Protection	Yes/No	No		
AB.14.1.2	Supply Over current Protection	Yes/No	Yes		
AB.14.1.3	Supply 3-Phase Short Circuit Protection	Yes/No	Yes		
AB.14.1.4	Supply Phase to Ground Protection	Yes/No	Yes		
AB.14.1.5	Over-current / Over-Load and ground Fault protection,	Yes/No	Yes		
AB.14.1.6	Over-current Alarm	Yes/No	Yes		
AB.14.1.7	Reverse Power Protection	Yes/No	Yes		
AB.14.1.8	Differential Protection	Yes/No	No		
AB.14.1.9	Loss of Excitation / Field Protection	Yes/No	Yes		
AB.14.1.10	Negative Phase Sequence Protection	Yes/No	Yes		
AB.14.1.11	Winding Temperature measurement	Yes/No	Yes		
AB.14.1.12	Over flux Protection	Yes/No	Yes		
AB.14.1.13	Over Voltage Protection	Yes/No	Yes		
AB.14.1.14	Field Over-Current / Overheating protection	Yes/No	Yes		
AB.14.1.15	Over speed trip protection (Mechanical Protection)	Yes/No	Yes		

AB.14.1.16	Mains decoupling relay (Opens the Diesel Generator breaker when synchronized with the main supply for testing purposes and the main supply fails)	Yes/No	Yes		
------------	---	--------	-----	--	--

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.14.1.17	Under Voltage protection,	Yes/No	Yes		
AB.14.1.18	Under/Over frequency protection	Yes/No	Yes		
AB.14.2	Mechanical				
AB.14.2.1	Crankcase mist detection,	Yes/No	Yes		
AB.14.2.2	Bearing Temperature High,	Yes/No	Yes		
AB.14.2.3	Overspeed trip,	Yes/No	Yes		
AB.14.2.4	Generator fault trip	Yes/No	Yes		
AB.14.2.5	Lubricating oil pressure very low	Yes/No	Yes		
AB.14.2.6	Oil Temperature very high	Yes/No	Yes		
AB.14.2.7	Cooling water temperature very high.	Yes/No	Yes		
AB.14.2.8	Overcrank trip alarm.	Yes/No	Yes		
AB.14.2.9	Low coolant level alarm	Yes/No	Yes		
AB.14.2.10	Low lube oil pressure pre-alarm	Yes/No	Yes		
AB.14.2.11	Low oil temperature pre-alarm	Yes/No	Yes		
AB.14.2.12	High Cooling water temperature pre-alarm	Yes/No	Yes		
AB.14.5	CT (s) 1 Neutral Star Point				
AB.14.5.1	Application				
AB.14.5.2	Location				

AB.14.5.3	Number per Set		3		
AB.14.5.4	Type				

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.14.5.5	Class				
AB.14.5.6	Number of Cores				
AB.14.5.7	ratio				
AB.14.5.8	Burden				
AB.14.6	CT (s) 2 Governor And Engine Control System				
AB.14.6.1	Application				
AB.14.6.2	Location				
AB.14.6.3	Number per Set		3		
AB.14.6.4	Type				
AB.14.6.5	Class				
AB.14.6.6	Number of Cores				
AB.14.6.7	ratio				
AB.14.6.8	Burden				
AB.15	Automatic Voltage Regulator (AVR)				
AB.15.1	Manufacturer				
AB.15.2	Type and Model				

AB.15.3	Response Rate	V/s			
AB.15.4	Regulator operating time	s			
AB.15.5	Maximum excitation required to maintain rated load at steady state	A			

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.15.6	Maximum Excitation required during transient conditions	A			
AB.15.7	Transient Voltage deviation	%	20		
AB.15.8	Voltage Regulation from 0 to 100% rated Load	±%			
AB.15.9	Manual Voltage adjustment range	%	90 - 110		
AB.15.10	Maximum Voltage Droop over the Load Range 0 to 100%	%	2		
AB.15.11	Regulation Drift limit	%	0.50%		
AB.15.12	Sensitivity	%			
AB.16	Exciter				
AB.16.1	Manufacturer				
AB.16.2	Type and Model				
AB.16.3	Rating	kVA			
AB.16.4	Rated Voltage	V			
AB.16.5	Rated Current	A			

AB.16.6	Exciter System Current when Generator is at full Load and 0.8 p.f	Ampere dc			
AB.16.7	Exciter system current when Generator is at full Load and 0.8 p.f				
AB.16.8	Exciter No Load current	Ampere dc			
AB.16.9	Exciter System resistance normalized at 75°C	Ω			

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.16.10	Permanent Magnet Generator for Voltage Regulator Power	Yes/No	Yes		
AB.16.11	Response Rate	V/s			
AB.16.12	Temperature Rise of Excitation System	K			
AB.16.13	Insulation Class of Exciter system		F or H		
AB.16.14	Time Constant of Exciter Build-up	s			
AB.16.15	Current series boost provided	Yes/No	if required		
AB.17	Governor				
AB.17.1	Manufacturer				
AB.17.2	Electronic Governor Controller	P (Proportional)/ PI (Proportional Integral)/ PID (Proportional Integral Differential)			
AB.17.3	Speed Manual Adjustment Range	%	±2.5		
AB.17.4	Drop Setting Range	%	0 to 7		

AB.18	Generator Set Outer Coating				
AB.18.1	Corrosion Protection required	Non-Corrosive/ High Corrosive/ Very High Corrosive	Very High Corrosive		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.18.2	Main tank external final colour coding	SANS 10140			
AB.19	Generator Set Starting System				
AB.19.1.1	Starting Method	Air Battery			
AB.19.1.2	Supply Air Pressure required	kPa			
AB.19.1.3	Supply Air Minimum Flow Rate	m ³ /s			
AB.19.1.4	Air Supply quality required				
AB.19.1.5	Air Supply Flanch details				
AB.19.1.6	Number of Starting Attempts		5		
AB.19.1.7	Crank time until over-crank lockout	s			
AB.19.1.8	Redundant Starting System (Battery Banks, Starter Motor And Charger)	Yes/No	Yes		
AB.19.5	Electrical Starter System				
AB.19.5.1	Starter System Manufacturer				
AB.19.5.2	Voltage of Starting System	V			
AB.19.5.3	Nominal Power of Starting Motor	kW			

AB.19.5.4	Maximum cranking current of Starting Motor (Cold Cranking Amps-CCA)	A			
AB.19.5.4	Battery Type	AGM/VRLA	5 year Maintenance Free AGM		
AB.19.5.5	Number of Battery banks per Gen Set				

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.19.5.6	Number of Batteries per battery bank				
AB.19.5.7	Voltage of each battery	V			
AB.19.5.8	Final Discharge voltage	V			
AB.19.5.9	Battery Capacity	Ah			
AB.19.5.10	Battery Earthing pole		Negative		
AB.19.5.11	Earthing and Bonding Conductor		Copper		
AB.19.6	Battery Charger				
AB.19.6.1	Available input voltage	V	220V or 400V		
AB.19.6.2	Battery Charger Manufacturer				
AB.19.6.3	Battery Charger Type				
AB.19.6.4	Battery Charger model				
AB.19.6.5	Charger Rated Output	kW			
AB.19.6.6	Charger rated Output Voltage	Vdc			
AB.19.6.7	Charger rated Output Current	A			
AB.19.6.8	DC Voltage ripple amplitude when operating without batteries	%	5		

AB.19.6.9	Charger Per Battery Unit	Yes/No	Yes		
AB.19.6.10	Batteries Shall Be Manufactured According to SANS1632	Yes/No	Yes		
AB.20	Generator Set Neutral Earthing System				

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.20.1	Generator Neutral Earthing method				
AB.20.2	Supply Neutral Contactor	Yes/No	No		
AB.20.3	Neutral Contactor Manufacturer				
AB.20.4	Neutral Contactor type				
AB.20.5	Neutral Contactor maximum continuous current	A			
AB.20.6	Rated Phase to Earth fault current (10s)	A			
AB.20.7	Contactor BIL (Basic Insulation Level)	kV, peak			
AB.20.8	Contactor Power Frequency withstand Voltage	kVrms			
AB.20.9	Supply Neutral Earthing Resistor	Yes/No	Yes		
AB.20.10	Neutral Earthing Resistor Manufacturer				
AB.20.11	Neutral Earthing Resistor Type				
AB.20.12	Neutral Earthing Resistor Nominal Voltage	kV			
AB.20.13	Neutral Earthing Resistor Insulation Material				
AB.20.14	Neutral Earthing Resistor Resistance at 100°C	Ω			
AB.20.15	Neutral Earthing Resistor rated phase to Earth Fault current (10s)	A			

AB.20.16	Impedance of Resistor	Ω			
AB.20.17	Neutral Earthing Resistor BIL (Basic Insulation Level)	kV, peak	75		
AB.20.18	Neutral Earthing Resistor Power Frequency Withstand Voltage	kV rms	28		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.21	Generator Set Vibrations Limits				
AB.21.1	Max engine-generator set vibration in horizontal, vertical, and axial	mm, rms	0.15		
AB.21.2	Overall velocity limit	mm, rms	24		
AB.21.3	Maximum speed relative to rated speed, for which the above limits apply	%	110		
AB.21.4	Maximum vibration peak force transmitted to the floor through Isolation system	N			
AB.21.5	Vibration damper type				
AB.21.6	Number of Vibration Dampers				
AB.21.7	Wr ² of the Engine	kgm ²			
AB.21.8	Wr ² of the Generator Rotor	kgm ²			
AB.21.9	Wr ² of the coupling	kgm ²			
AB.22	Weights and Dimensions				
AB.22.1	Dimensions				
AB.22.1.1	Overall Length				

AB.22.1.2	Overall Width				
AB.22.1.3	Overall Height from floor				
AB.22.1.4	Required end clearances				

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.22.1.5	Generator Length				
AB.22.1.6	Generator Width				
AB.22.1.7	Generator Height from floor				
AB.22.1.8	Engine Length				
AB.22.1.9	Engine Width				
AB.22.1.10	Engine Height from floor				
AB.22.2	Weights				
AB.22.2.1	Engine weight	kg			
AB.22.2.2	Generator Weight total	kg			
AB.22.2.3	Generator Stator Copper Weight	kg			
AB.22.2.4	Generator Stator Machine steel weight	kg			
AB.22.2.5	Generator Rotor Copper Weight	kg			
AB.22.2.6	Generator Rotor Machine steel weight	kg			
AB.22.2.7	Shipping Weight of Engine	kg			
AB.22.2.8	Shipping Weight of Generator	kg			
AB.22.2.9	Shipping weight of the heaviest piece to be handled	kg			

AB.23	Control system				
AB.23.1	Manufacturer				
AB.23.2	Type				

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.23.3	Controller Power Requirements	kW			
AB.23.4	Controller Voltage	V			
AB.23.5	Controller position		Stand Alone Control cabinet in close proximity to the Diesel Generator set		
AB.23.6	Local Alarms and Plant Status		To be displayed on a local HMI		
AB.23.7	Communication Protocol		Hardwired System		
AB.23.8	Diagnostic abilities required	Yes/No	Yes		
AB.23.9	Automatic Start	Yes/No	Yes		
AB.23.10	Remote Control System interface required	Yes/No	Yes		Employer's Engineer to provide Operating and Control Philosophy
AB.23.11	Manual Start	Yes/No	Yes		
AB.23.12	Isolate Function Inhibiting All Start Commands	Yes/No	Yes		
AB.23.13	Manual Sync function	Yes/No	No		

AB.23.14	Local DG alarm annunciator panel required	Yes/No	Yes		Employer's Engineer to provide Operating and Control Philosophy
AB.24	Air Flows				

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.24.1	Combustion Airflow Total	m ³ /s			
AB.24.2	Exhaust Airflow	m ³ /s			
AB.25	Heat Rejection to the room by:				
AB.25.1	The Engine	kW			
AB.25.2	Oil Cooler	kW			
AB.25.3	Generator	kW			
AB.25.4	Engine water Radiator	kW			
AB.25.5	Radiator required Airflow Rate	m ³ /s			
AB.25.6	Other Accessories	kW			
AB.26	Emissions				
AB.26.1	NOx	mg/nm ³			
AB.26.2	CO	mg/nm ³			
AB.26.3	HC	mg/nm ³			

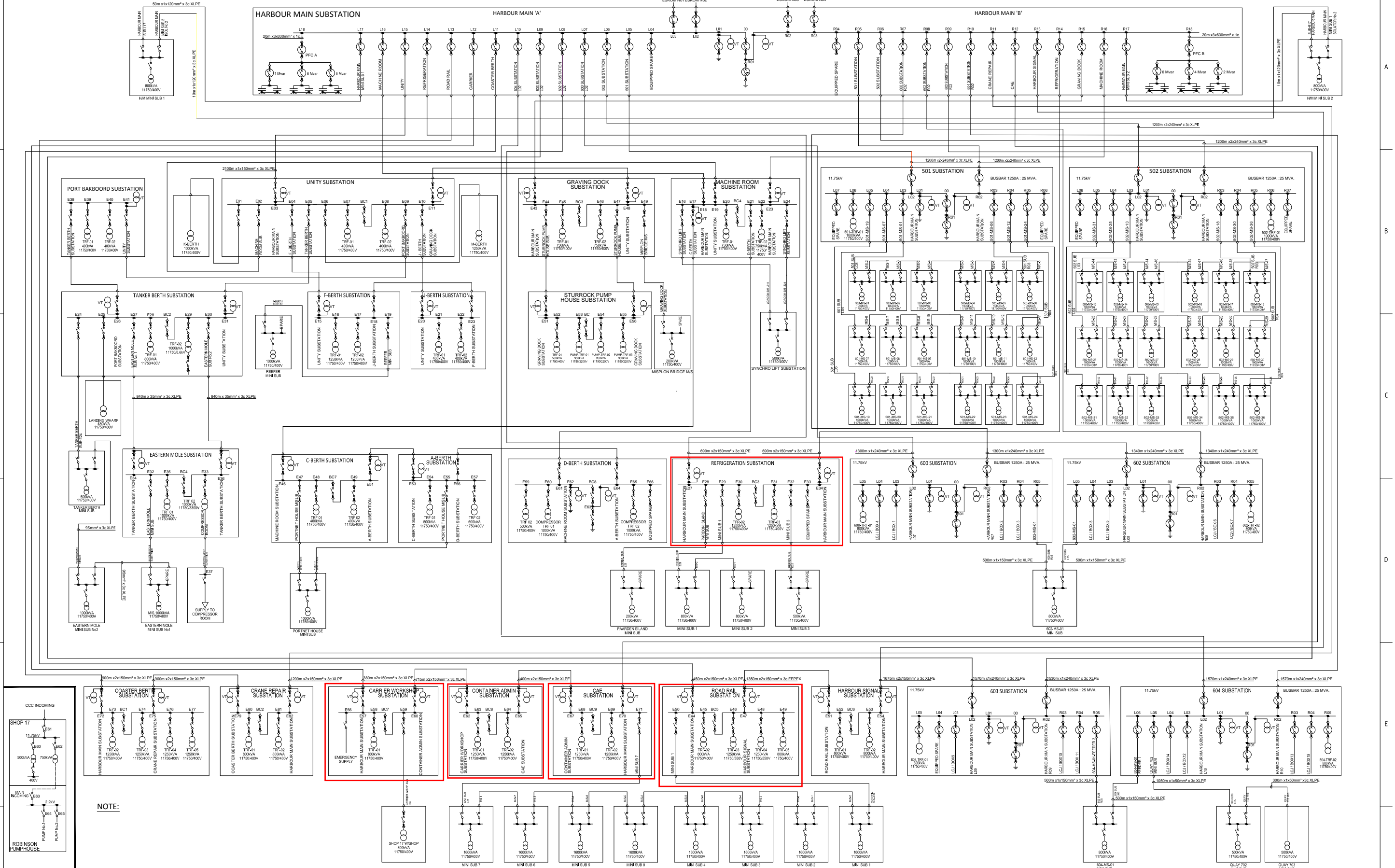
AB.26.4	PM	mg/nm ³			
AB.27	Tests				
AB.27.1	Perform Factory Acceptance Test in accordance with SANS 8528 - 6	Yes/No	Yes (Groups C and M)		
AB.27.2	Perform Efficiency Test to verify AB.28	Yes/No	Yes		

Item	Requirement		Schedule A: User Requirement	Schedule B: Tender Guaranteed Values	Remarks /alterations, etc.
AB.27.3	Perform 100% step load test	Yes/No	Yes		
AB.28	Efficiency Evaluation				
AB.28.1	R	Rand/Liter			
AB.28.2	P Ratio1	hours			
AB.28.3	P Ratio2	hours			
AB.28.4	P Ratio3	hours			
AB.28.5	P Ratio3	hours			
AB.28.6	Fuel Consumption at Full Load	kg / hour			
AB.28.7	Fuel Consumption at ¾Load	kg / hour			
AB.28.8	Fuel Consumption at ½ Load	kg / hour			
AB.28.9	Fuel Consumption at ⅓ Load	kg / hour			

TECHNICAL DRAWING:

Electrical Port Reticulation _ MV Single Line Diagram

DO NOT SCALE - IF IN DOUBT, ASK
 ESKOM NOT ESKOM N2
 BUS SECTION TO BE OPERATED IN CLOSED POSITION FOR PFC.



NOTE:

ROBINSON PUMPHOUSE

SHOP 17

MINI SUB NO. 1

MINI SUB NO. 2

MINI SUB NO. 3

MINI SUB NO. 4

MINI SUB NO. 5

MINI SUB NO. 6

MINI SUB NO. 7

MINI SUB NO. 8

MINI SUB NO. 9

MINI SUB NO. 10

NO.	DESCRIPTION	BY	CHKD	APP'D	DATE
10	ADDED BERGANCAPE MINISUB	MR	AJ		26-03-15
9	UPDATED FOR RECORD PURPOSES	PS	MR.		13/06/19
8	ISSUED FOR CONSTRUCTION	SK	BA	PK	12/09/20
7	ISSUED FOR RECORD	SK	BA	PK	12/04/05
6	ISSUED FOR CONSTRUCTION	SK	BA	PK	12/02/19
5D	S-BERTH ALTERED TO D-BERTH	PS	RR		11/10/19
5C	ADDITIONAL LABELS TO MINI SUB	PS	RR		11/10/18
5B	MINI SUB CONFIGURATION CHANGE	PS	RR		11/10/14
5A	OVERALL UPDATE TO DRAWING	PS	MR		11/10/07

NO.	DESCRIPTION	BY	CHKD	APP'D	DATE
11	OVERALL UPDATE				06/06/16

CAPE TOWN CONTAINER TERMINAL

PORT AREA

ELECTRICAL RETICULATION

OVERALL 11.75 kV

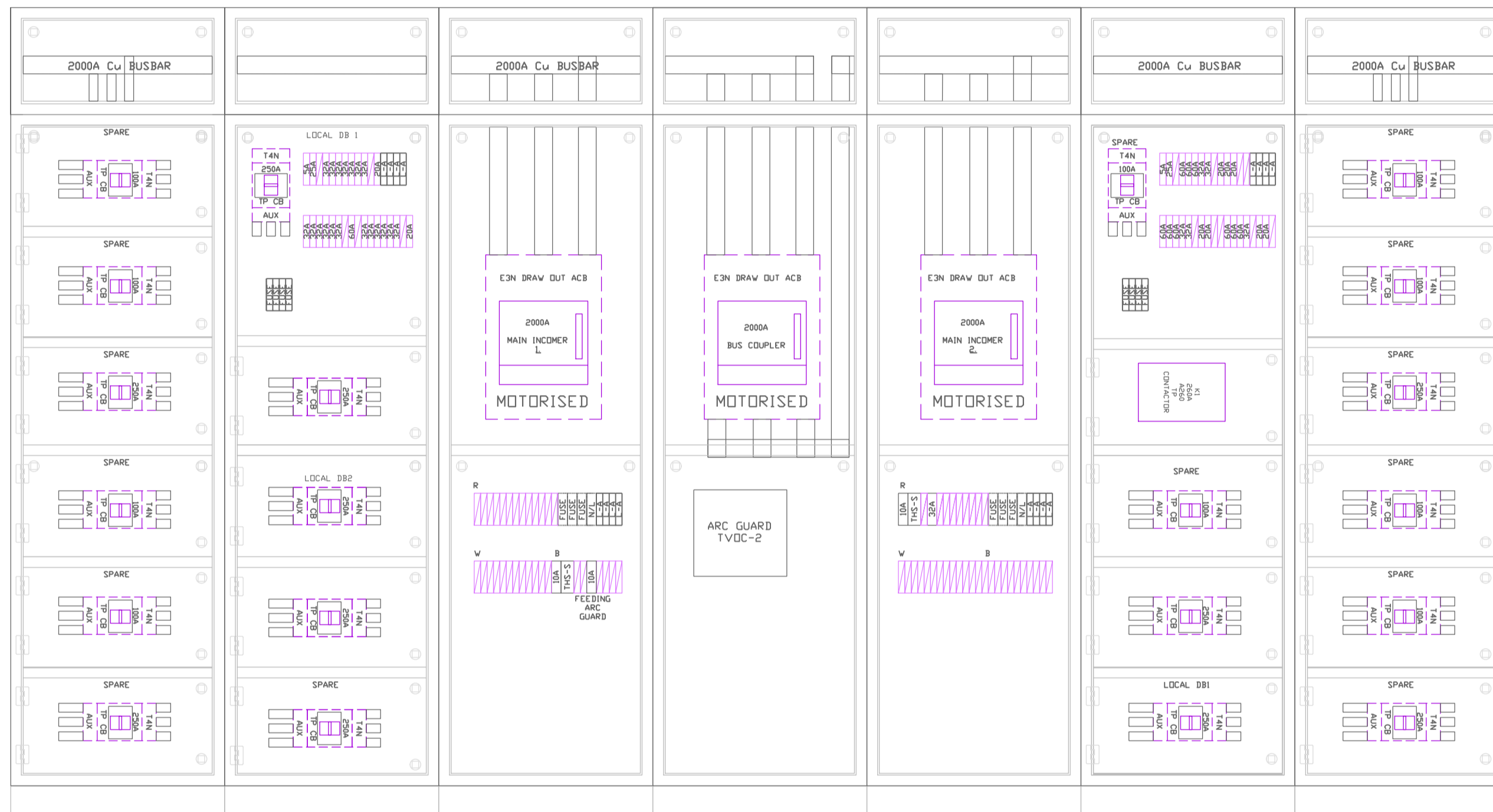
SINGLE LINE DIAGRAM

PROJECT NUMBER: H500206
 SHEET: 1-413-E-SL-0011-01-11
 DATE: 2006/12/01

TECHNICAL DRAWING:

ROAD RAIL SUBSTATION

LV Panel 1



NOTES :

1. THIS DRAWING FOR EL&P ONLY.
2. A CERTIFICATE OF COMPLIANCE TO BE COMPLETED BY CONTRACTOR ON COMPLETION OF WORK.
3. ALL D.B.'S AND ISOLATORS TO BE CLEARLY LABELLED.

TYPE :	FLOORSTANDING
MATERIAL :	3CR12 STEEL
IP RATING :	40
FORM :	3B
DOORS :	NO
DEPTH :	750mm
PANEL CATCHES :	SQUARE KEY
PANEL HINGES :	BUTT HINGES
DOOR CATCHES :	N/A
DOOR HINGES :	N/A
ACCESS :	FRONT & REAR
CABLE ENTRY :	BOTTOM
CABLE EXIT :	BOTTOM
COLOR :	BRUNSWICK GREEN
FAULT LEVEL :	25/20kV
SPECIAL NOTES :	

NOTES

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CAPE TOWN ROAD RAIL SUBSTATION			
CONCEPT LV PANEL LAYOUT			
PROJECT NUMBER	OD	FBS	DIS
DRAWING NO.	SHEET	REV	ID
			TD

DRAWING NO.	REFERENCE
	REFERENCE DRAWINGS

TECHNICAL DRAWING:

ROAD RAIL SUBSTATION

LV Panel

TECHNICAL DRAWING:

ROAD RAIL SUBSTATION

LV Single Line

TECHNICAL DRAWING:

ROAD RAIL SUBSTATION

LV Single Line 1

TECHNICAL DRAWING:

ROAD RAIL SUBSTATION

MV Single Line and Floor Layout

TECHNICAL DRAWING:

REFRIGERATION SUBSTATION

LV Panel

TECHNICAL DRAWING:

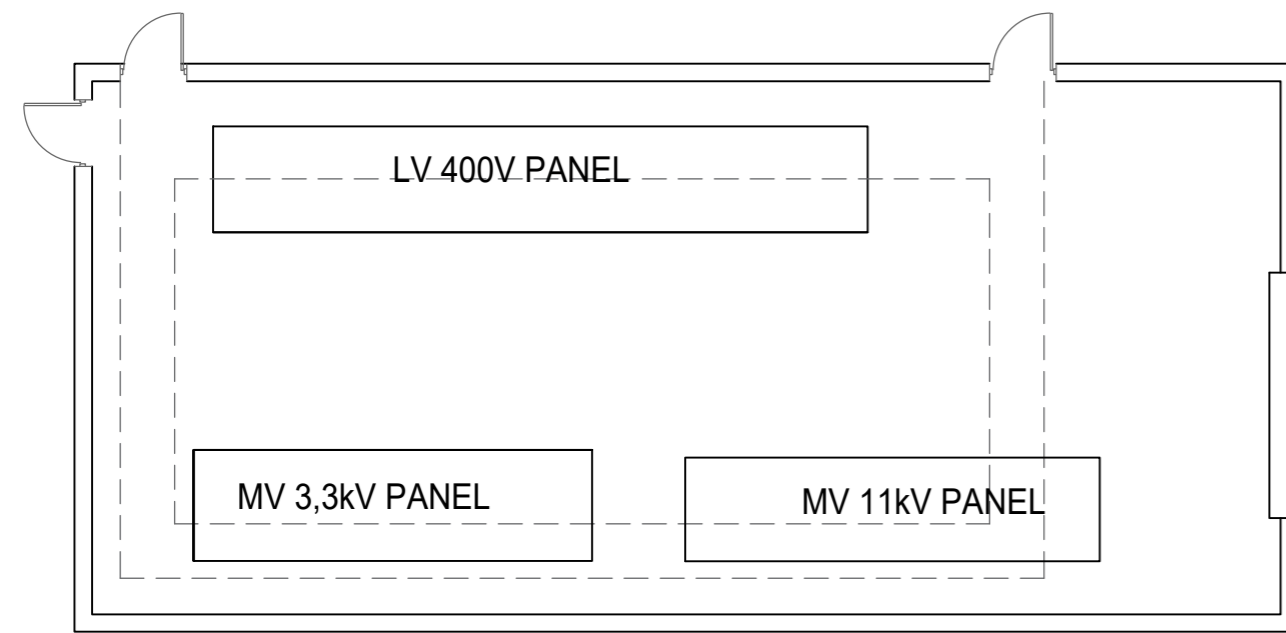
REFRIGERATION SUBSTATION

LV Single Line

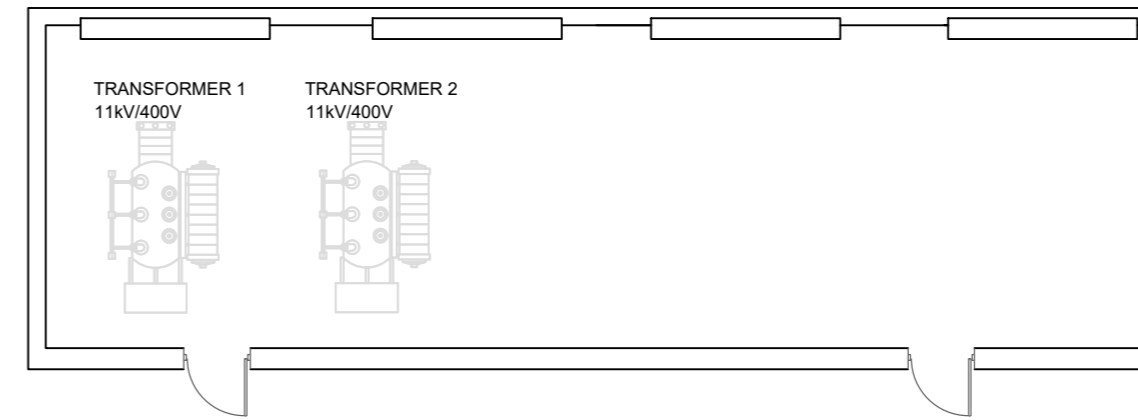
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REFRIGERATION SUBSTATION

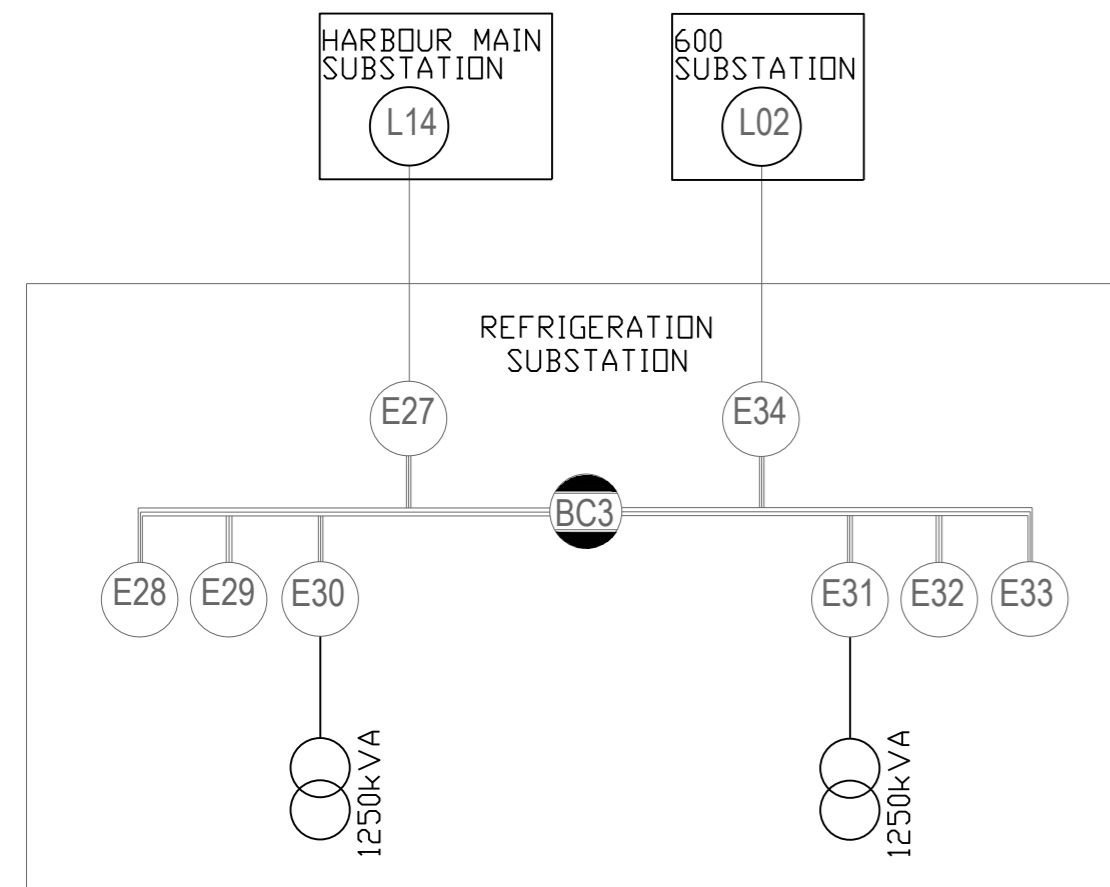
MV Single Line and Floor Plan Layout



SCALE 1:100
REFRIGERATION SUBSTATION EXISTING MV FLOOR PLAN



SCALE 1:100
REFRIGERATION SUBSTATION TRF FLOOR PLAN



REFRIGERATION SUBSTATION
LINE DIAGRAM

NOTES:

1. TRANSFORMER CAPACITY SHOWN IN KVA UNLESS OTHERWISE INDICATED
2. DEVICE NORMALLY OPEN POSITION
3. DEVICE MAY BE OPERATED WITHOUT REFERENCE TO "CONTROL" BUT WORK PERMITS MUST BE THROUGH CONTROL

NOTES

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TITLE	NAME	SIGN	DATE	NAME	SIGN	DATE	DATE
				S. KHOZA			
				SIGNATURE			
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 TRANSNET PORT TERMINALS
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**CAPE TOWN
REFRIGERATION SUBSTATION**

MV FLOOR LAYOUT AND SINGLE LINE DRAWING

PROJECT NUMBER	OD	FBS	DIS	TYPE	DRAWING NO.	SHEET	REV	ID
								TD

DRAWING NO.	REFERENCE
REFERENCE DRAWINGS	

TECHNICAL DRAWING:

CONTAINER ADMIN SUBSTATION

LV Panel

TECHNICAL DRAWING:

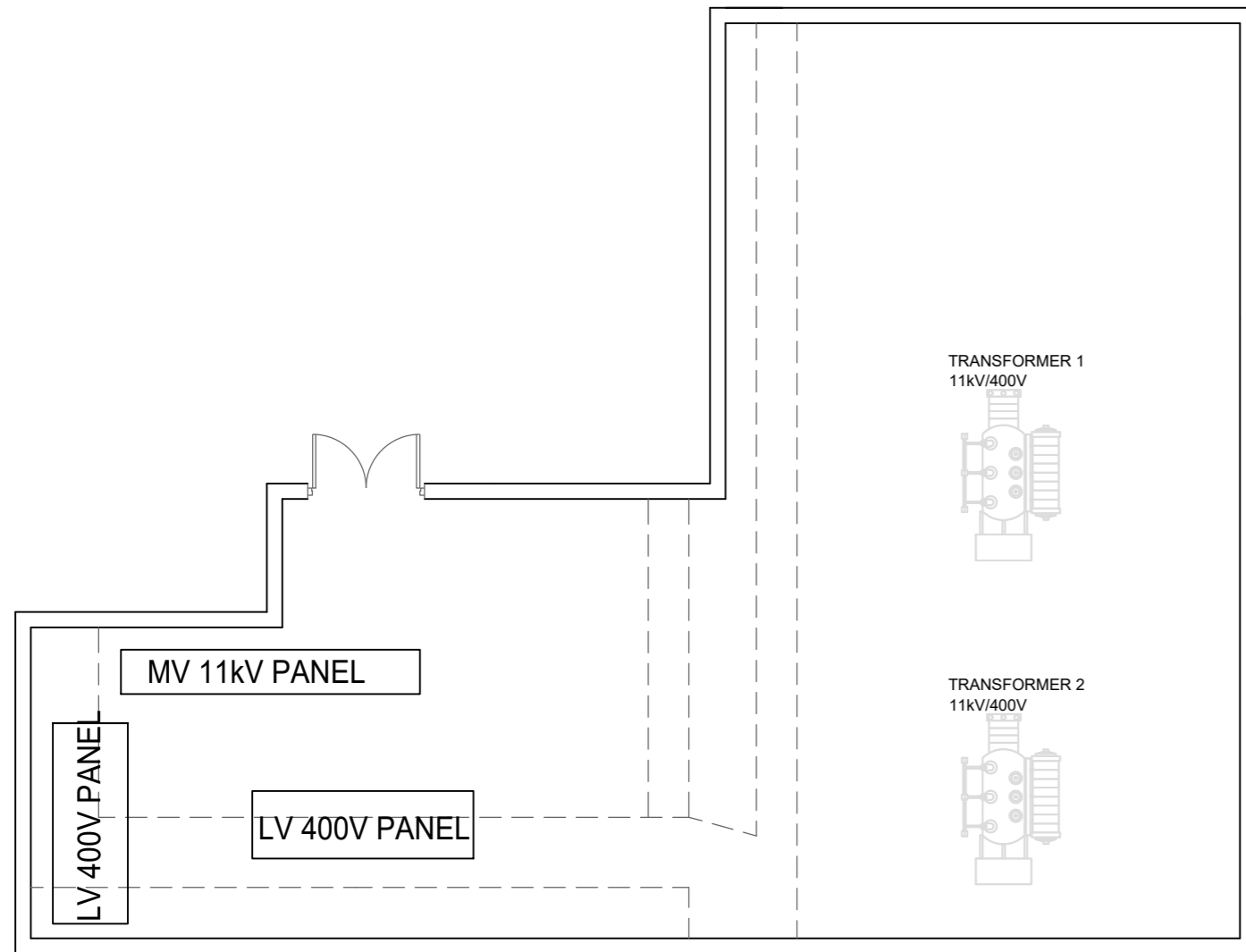
CONTAINER ADMIN SUBSTATION

LV Single Line

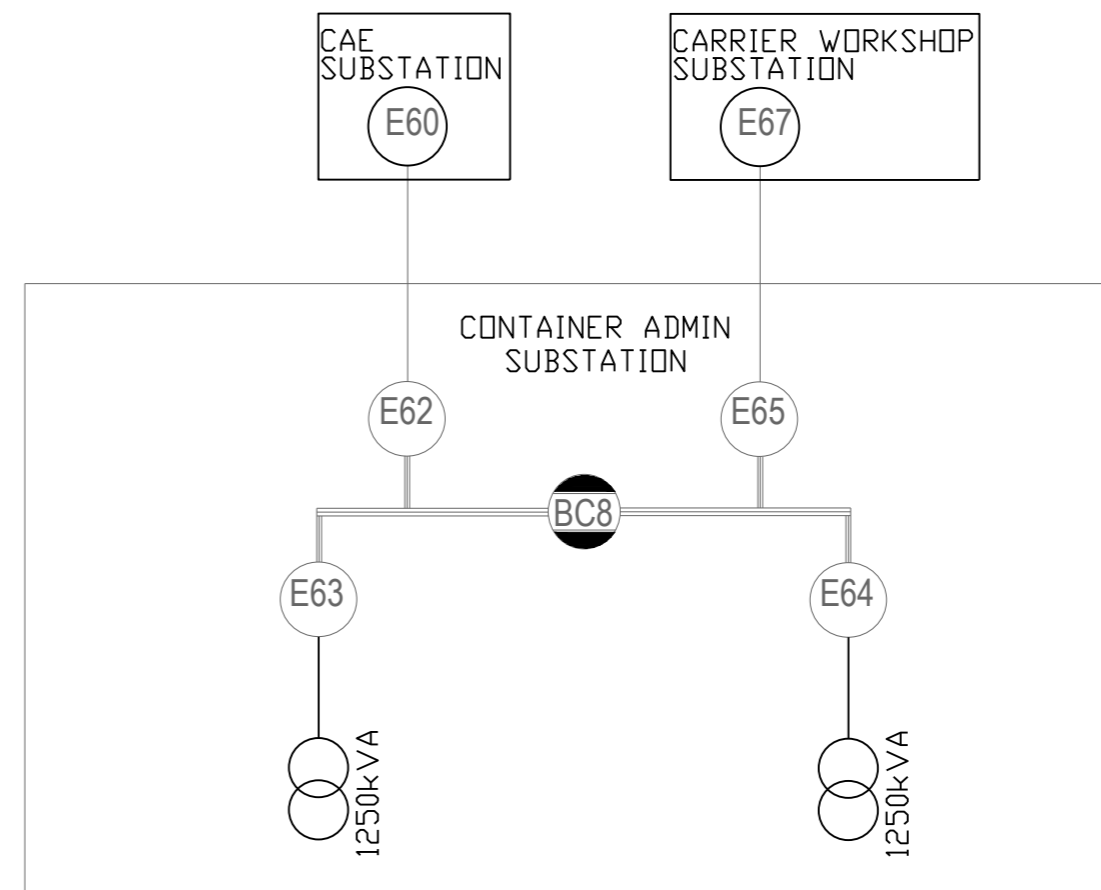
TECHNICAL DRAWING:

CONTAINER ADMIN SUBSTATION

MV Single Line and Floor Layout



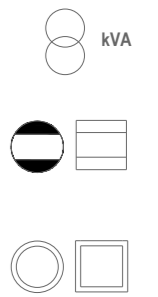
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CONTAINER ADMIN SUBSTATION EXISTING MV TRF FLOOR PLAN



CONTAINER ADMIN SUBSTATION
LINE DIAGRAM

NOTES:

1. TRANSFORMER CAPACITY SHOWN IN kVA UNLESS OTHERWISE INDICATED
2. DEVICE NORMALLY OPEN POSITION
3. DEVICE MAY BE OPERATED WITHOUT REFERENCE TO "CONTROL" BUT WORK PERMITS MUST BE THROUGH CONTROL



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202 ANTON LEMBEDE STREET
DURBAN

TEL: 031 361 1456

**CAPE TOWN
CONTAINER ADMIN SUBSTATION**

MV FLOOR LAYOUT AND SINGLE LINE DRAWING

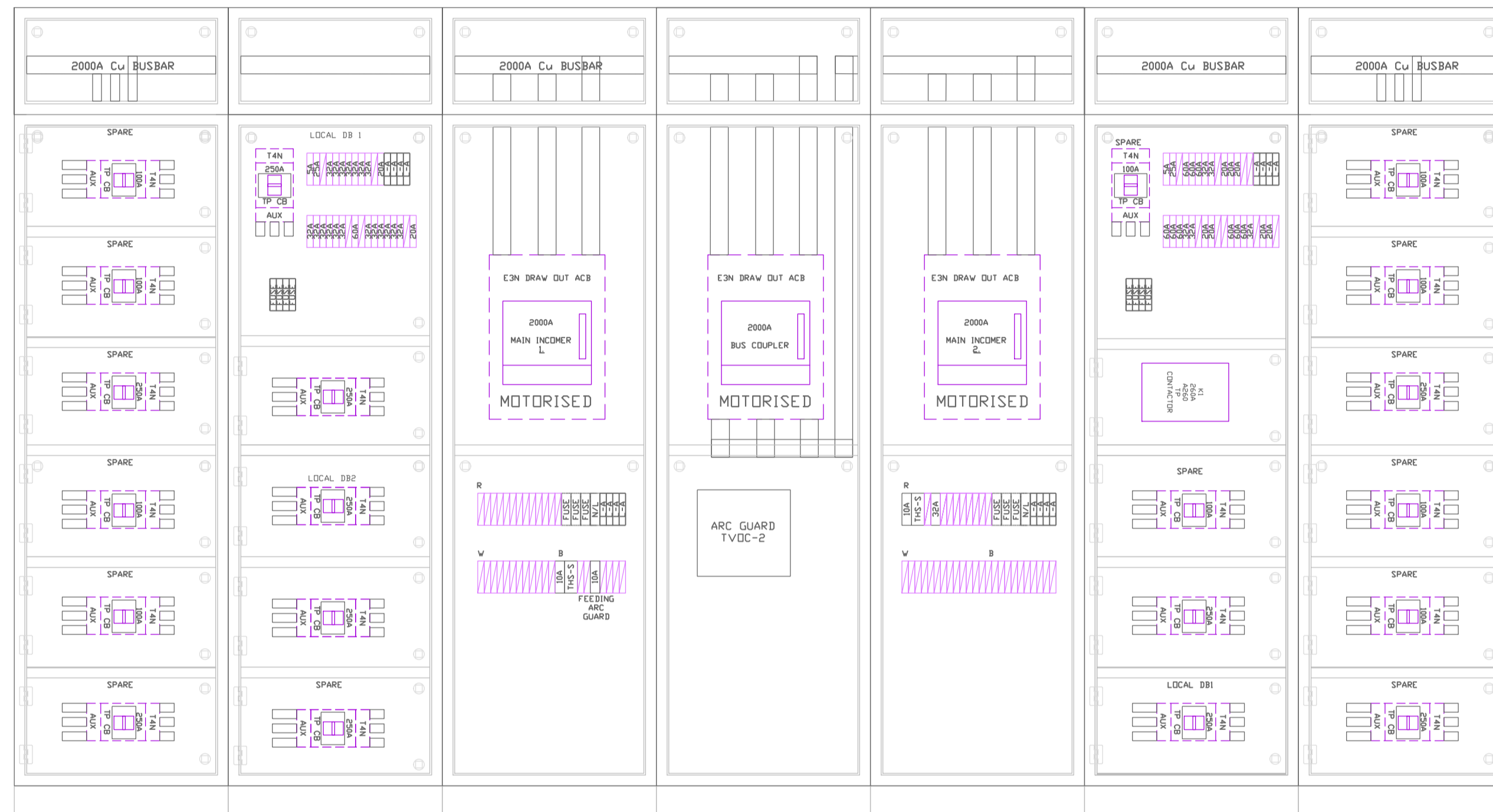
PROJECT NUMBER	OD	FBS	DIS	TYPE	DRAWING NO.	SHEET	REV	ID
								TD

A0

TECHNICAL DRAWING:

COASTER BERTH SUBSTATION

LV Panel



NOTES :

1. THIS DRAWING FOR EL&P ONLY.
2. A CERTIFICATE OF COMPLIANCE TO BE COMPLETED BY CONTRACTOR ON COMPLETION OF WORK.
3. ALL D.B.'S AND ISOLATORS TO BE CLEARLY LABELLED.

TYPE : FLOORSTANDING
MATERIAL : 3CR12 STEEL
IP RATING : 40
FORM : 3B
DOORS : NO
DEPTH : 750mm
PANEL CATCHES : SQUARE KEY
PANEL HINGES : BUTT HINGES
DOOR CATCHES : N/A
DOOR HINGES : N/A
ACCESS : FRONT & REAR
CABLE ENTRY : BOTTOM
CABLE EXIT : BOTTOM
COLOR : BRUNSWICK GREEN
FAULT LEVEL : 25/20kV
SPECIAL NOTES :

NOTES

1. DO NOT SCALE DRAWING - ONLY DIMENSIONS SHOWN TO BE USED.
2. THE CONTRACTOR SHALL VERIFY ALL CONDITIONS, DIMENSIONS AND LEVELS ON THE SITE AND NOTIFY THE NEC SUPERVISOR OF ANY VARIATIONS BEFORE CONSTRUCTION.

NO.	DESCRIPTION	BY	CHKD	APPD	DATE
REVISIONS					
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				SCALE :			

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		<small>TEL: 031 361 1696 FAX: 0866 770815</small>	
TRANSNET PORT TERMINALS			
CAPE TOWN COASTER BERTH SUBSTATION			
CONCEPT LV PANEL LAYOUT			
PROJECT NUMBER	OD	FBS	DIS
DRAWING NO.	SHEET	REV	ID
			TD

DRAWING NO.	REFERENCE
	REFERENCE DRAWINGS

TECHNICAL DRAWING:

COASTER BERTH SUBSTATION

LV Panel 1

TECHNICAL DRAWING:

COASTER BERTH SUBSTATION

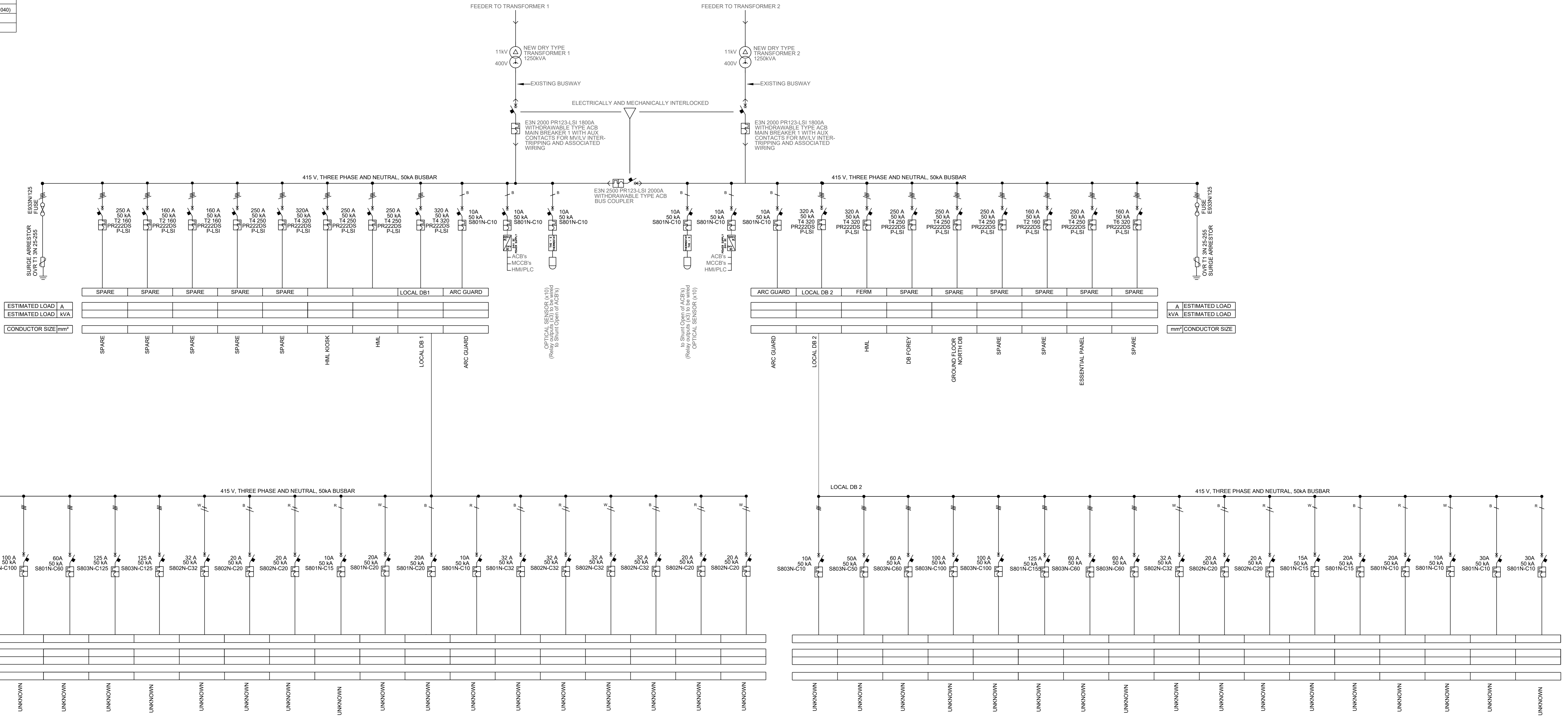
LV Single Line 1

TECHNICAL DRAWING:

COASTER BERTH SUBSTATION

LV Single Line 2

LV PANEL SPECIFICATION	
SPARE WAYS	
DISTRIBUTION BOARD TYPE	FLOOR STANDING
MATERIAL	3CR12
THICKNESS OF MATERIAL	2mm
PAINT TYPE	POWDER COATED (40 MICRONS)
FRAME COLOUR	BRUNSWICK GREEN
FORM TYPE	FORM 3B
MANUFACTURER	
ACB/MCCB / MCB MAKE	ABB
HMI/PLC MAKE	UNITRONIC/EAST COAST SOLUTIONS (V1040)
PFR MAKE	ABB (CM - PVE)
TERMINALS MAKE	ABB (ZS - RANGE)



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NOTES

TERMINATION: CONTRACTOR TO ENSURE THAT ALL NEW CABLE TERMINATIONS BE MADE ON SABS APPROVED TERMINAL RAILS AND SHALL BE LOCATED IN THE SAME POSITIONS AS PER EXISTING INSTALLATIONS. NO CABLE JOINTS WILL BE PERMITTED.

MCCB'S: SHALL BE FITTED WITH FRONT LEVER MECHANISM LOCK (FLANGE) SHALL BE FITTED WITH X3 AND X4 CONNECTORS. VM210 SHALL BE ALLOWED FOR (ONE PER FIVE MCCB'S). SHALL BE FITTED WITH AUX - E (AUXILIARIES).

POWER SUPPLY: 24V DC POWER SUPPLY SUITABLE RATED FOR ACB'S, MCCB'S AND HMI/PLC SHALL BE ALLOWED FOR TO SUPPLY WHARF PLUG SAFETY CIRCUIT.

HMI/PLC: GSM MODEM FOR TRIP STATUS AND DATA ACQUISITION SHALL BE FITTED. HMI/PLC SHALL DISPLAY VOLTAGE, CURRENT, POWER(S), TRIPS AND ETC FOR EACH AND EVERY MCCB.

HEATERS: ANTI-CONDENSATION HEATERS 230V SHALL BE PROVIDED FOR ALL PANEL SECTIONS, AND BE CONTROLLED BY THIS - S AS SPECIFIED.

ARC GUARD: RELAY (R1) TO OPEN MAIN BREAKER 1 DURING ARC FLASH. RELAY (R2) TO OPEN MAIN BREAKER 2 DURING ARC FLASH. IN ADDITION TO THE ABOVE RELAY (R1) OR RELAY (2) WILL OPEN BUS COUPLER DURING ARC FLASH AS WELL. RELAY (R3) SHALL BE WIRED TO HMI/PLC.

AUDIBLE AND VISUAL ALARM: CONTRACTOR SHALL ALLOW FOR INSTALLATION OF AUDIBLE AND VISUAL ALARM OUTSIDE SUB STATION. CONTROLLED BY THE THIS - S THERMOSTATS.

LIGHT BARRIERS: CONTRACTOR SHALL ALLOW FOR LIGHT BARRIERS IN BUSBAR CHAMBER.

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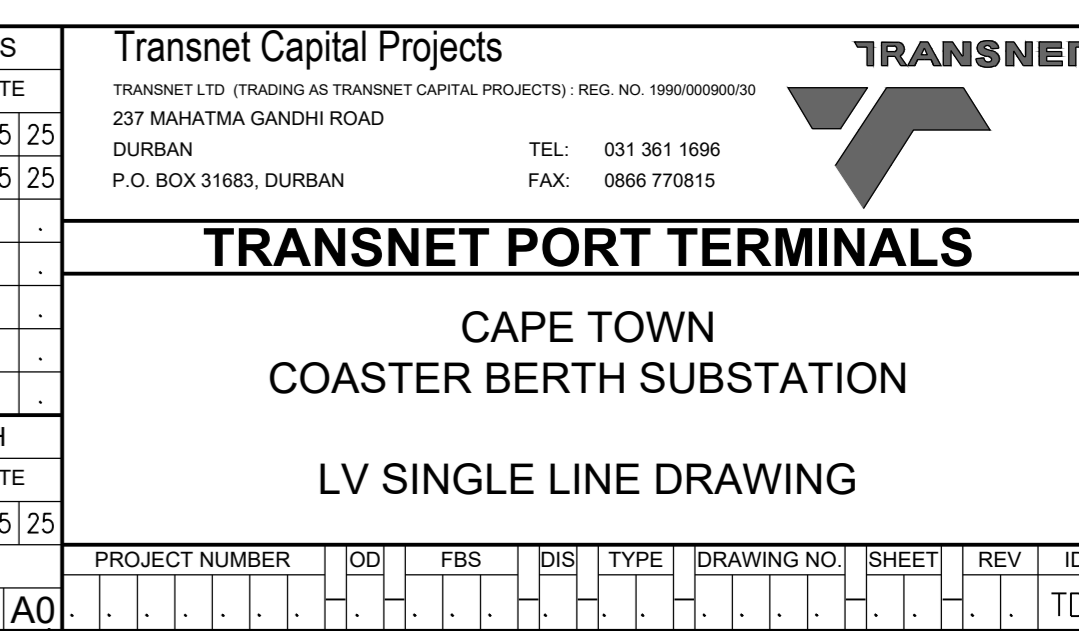
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 237 MAHATMA GANDHI ROAD
 DURBAN
 P.O. BOX 31963, DURBAN
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 FAX: 031 961 1695

TRANSNET PORT TERMINALS

CAPE TOWN
 COASTER BERTH SUBSTATION
 LV SINGLE LINE DRAWING



TECHNICAL DRAWING:

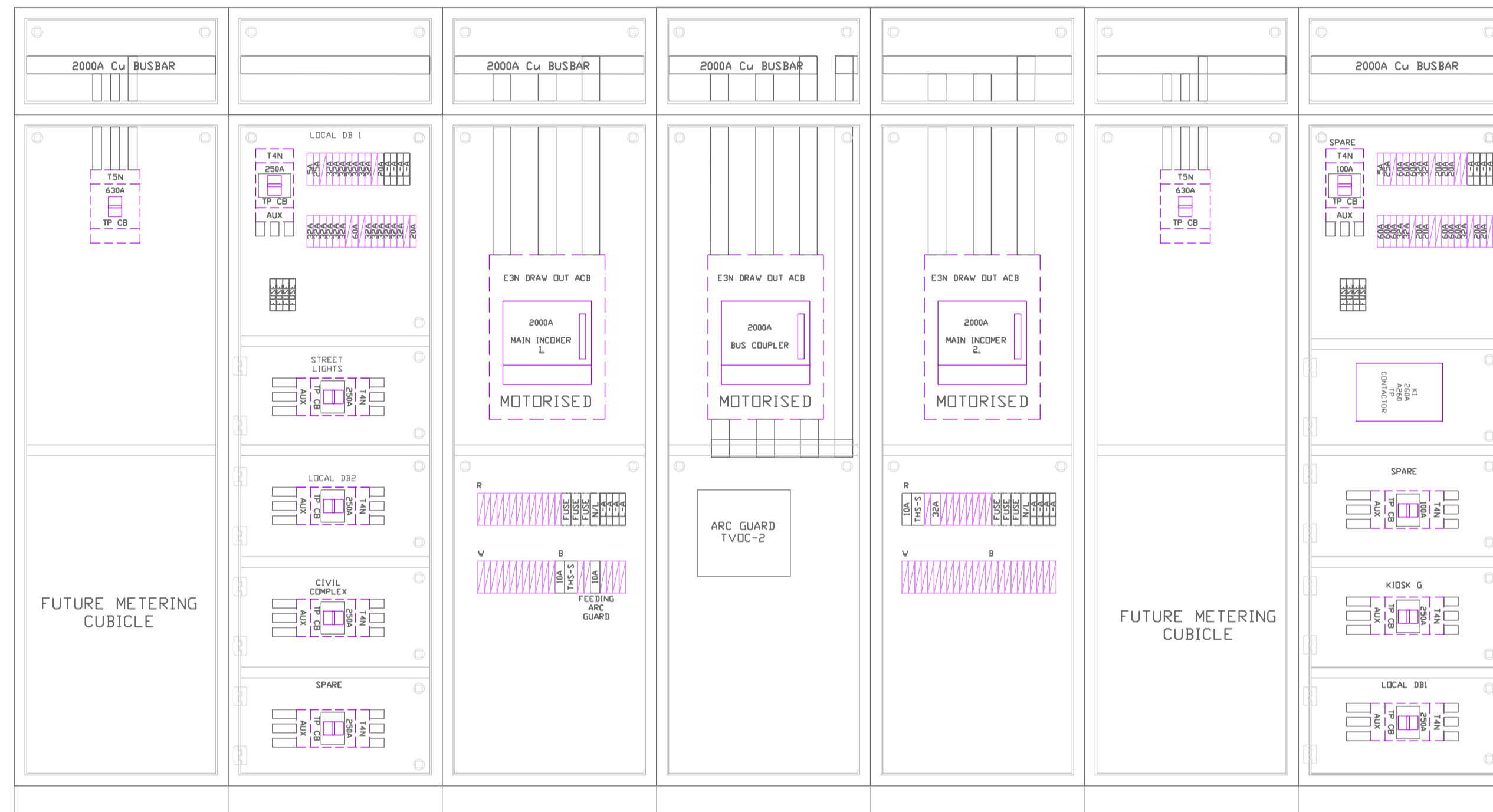
COASTER BERTH SUBSTATION

MV Single Line and Floor Plan Layout

TECHNICAL DRAWING:

CAE SUBSTATION

LV Panel



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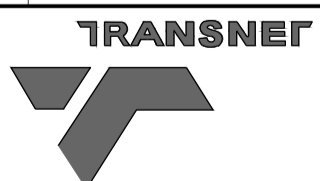
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TRANSNET PORT TERMINALS

CAPE TOWN
CAE SUBSTATION

CONCEPT LV PANEL LAYOUT

PROJECT NUMBER	OD	FBS	DIS	TYPE	DRAWING NO.	SHEET	REV	ID

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TECHNICAL DRAWING:

CAE SUBSTATION

LV Single Line

TECHNICAL DRAWING:

CAE SUBSTATION

MV Single Line and Floor Plan Layout

