ANNEXURE 6: DETAIL SCOPE OF WORK (PROJECT SPECIFICATION)

REQUEST FOR TENDERS – REFURBISHMENT OF BOOTH 3kV DC TRACTION SUBSTATION

TENDER NUMBER: HO/PT/ENG/(E)/000/00/0000

REQUEST FOR TENDERS – REFURBISHMENT OF BOOTH 3kV DC TRACTION SUBSTATION	
TENDER NUMBER: HO/PT/ENG/(E)/000/00/0000	

APPROVAL, OWNERSHIP & CONTROL

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RECORD OF CHANGES / AMENDMENTS

Version	Date	Name	Revision Description
00	15 September 2020	P vd Berg	Issued for Review
01	11 November 2020	P vd Berg	Issued for Tender
02	10 August 2021	P vd Berg	Issued for Acceptance

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1 INTRODUCTION

1.1 Background

The project arose out of the region wide asset condition assessment and regular inspections carried out by the regional staff. The inspection and condition assessment subsequently carried out by the Consultant indicated an accelerated deterioration of Booth 3kV DC traction substation. The project therefore seeks to address the following:

- Modernisation of the traction substation.
- Upgrade of the traction substation to cater for future load requirements.
- Ensure compliance with latest standards and regulations.

The nominal voltage of the existing MV incoming AC supply to the substation is 33kV and is supplied by the eThekwini Local Municipality as part of a ring-feed distribution configuration with other 33kV Transnet substation in the Bayhead and Port area. The nominal voltage level of the MV incoming AC supply to the refurbished substation will change to 11kV and will solely be supplied by the eThekwini Local Municipality, excluded from the feeding ring.

2 TERMINOLOGY AND ABBREVIATIONS

2.1 Terminology

The Client	PRASA Technical, also the Employer
Power Plant	This forms part of the main circuit through which the electrical power flows
Control Plant	LV equipment forming part of the substation control and protection system
Double Unit Substation	Substation having two traction transformers and two rectifier units, supplying power, independently from each other, to a common 3kV DC busbar
Employer	PRASA Technical, also the Client
R&H Rail	R&H Rail (Pty) Ltd, the Consultant
Take-Out substation work	Work that shall be priced by tenderers for inclusion as part of the Works but can be taken out of the Works on decision by PRASA.

2.2 Abbreviations

A	Ampère
AC	Alternating Current
AIS	Air Insulated Switchgear
BOQ	Bill of Quantities
BS	British Standards
°C	Degrees Celsius
CCD	Charge Couple Device
CCTV	Closed Circuit Television
CT	Current Transformer
DB	Distribution Board
DC	Direct Current
di/dt	Rate of rise of current (Ampere per second)
FAT	Factory Acceptance Test
fps	Frames Per Second
HDPE	High Density Polyethylene
HSCB	High Speed Circuit Breaker
HV	High Voltage. Nominal voltage levels greater than 44kV and less than 132kV
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IP	Internet Protocol
km	kilometre
kV	kilo Volt
kVA	kilo Volt Ampère
LV	Low Voltage. Nominal voltage levels up to and including 1kV AC and 1.5kV DC
l/s	Litres per second
m	metre
MCCB	Moulded Case Circuit Breaker
MCB	Miniature Circuit Breaker

mm	millimetre
MPa	Mega Pascal
MV	Medium Voltage. Nominal voltage levels greater than 1kV and less than 44kV
MVA	Mega Volt Ampère
MW	Mega Watt
NRS	National Rationalised Specifications
NTP	Network Time Protocol
NVR	Network Video Recording
OEM	Original Equipment Manufacturer
OHTE	Overhead Track Equipment
OHS	Occupational Health & Safety
PCB	Polychlorinated Biphenyls
PIDS	Perimeter Intruder Detection System
PoE	Power over Ethernet
PRASA	Passenger Railway Agency of South Africa
QA	Quality Assurance
SAT	Site Acceptance Test
SANS	South African National Standards
SoW	Scope of Work (Project Specification)
SSO	Switched Socket Outlet
TFR	Transnet Freight Rail
V	Volt
VT	Voltage Transformer
XLPE Cables	Cross Linked Polyethylene Insulated Cables

3 EXTENT OF THE WORKS

Note: Clause 3 of this scope of work (project specification) covers the high-level extent of the substation Works. This clause must be read in conjunction with the relevant clauses of this document as well as all the design drawings which constitutes the detailed technical requirements for this project. Any conflicting requirements or statements must be brought to the attention of PRASA Technical with immediate effect.

3.1 Summary of Scope (Project Specification)

a) The Works cover the detail design (shop drawings), for a complete substation including the power plant and the control plant with accompanying operating philosophy and design reports, manufacture, transportation to site, installation, testing, and commissioning of Booth 11kV AC to 3kV DC double unit traction substation.

b) The traction substation design shall comply with the applicable TFR/PRASA and related national / international standards, regulations and codes.

c) References shall be made to all Electrical, Architectural, Civil and Structural drawings issued as part of the tender, listed in Schedule A. These drawings are only issued for Tender purposes and may not be used for construction.

d) The high-level extent of the Works is as follows: -

1) Supply, construct and install a complete 11kV AC to 3kV DC double unit traction substation comprising of two 10.1MVA traction transformers, two 10MW rectifiers and associated equipment in the substation.

2) Supply and install two 100kVA, 2.36kV/400V AC 3-phase 50Hz auxiliary supply transformers.

3) Perform protection setting calculations and configuration of the various protection schemes proposed on the final approved designs.

4) The Contractor shall present the detail design and reports to the Employer for review and acceptance before ordering and / or installation of the equipment.

5) Once the detail designs (shop drawings and accompanying design reports) have been accepted by the Employer, the Contractor shall proceed with, but not limited to, the following: -

(i) Decommission all the existing equipment and remove them from site and demolish the existing substation buildings.

- Note that the refurbishment shall be executed in two phases. See clause 4 for a description of the phases.

(ii) Toxins such as Polychlorinated Biphenyls (PCB) that may be found in transformers' or wave filter capacitors' oil shall be handled and disposed of in a manner that is compliant with the environmental regulations.

(iii) The equipment that the PCB contaminated oil was found in, shall also be disposed of in an environmentally friendly manner, as above, and not be transported to the depot.

(iv) All asbestos products found in any equipment shall be handled by an authorised Contractor to do so and disposed of in a manner that is compliant with the environmental regulations. Records of such products shall be kept as well as where it was disposed of.

(v) All other re-usable decommissioned equipment shall be transported to the PRASA / Metrorail Durban Regional depot.

(vi) Building rubble and waste shall be transported and dumped in an environmentally approved dumping site.

(vii) Clear and prepare the site for construction.

(viii) Surveying and setting out of the Works.

(ix) Perform all the necessary earth works and compaction.

(x) Construction of the substation control building and stormwater drainage.

(xi) Supply and transportation of material and installation of the substation earth mat.

(xii) Manufacture various power plant equipment and control plant equipment.

(xiii) Supply, transportation and installation of all power and control plant equipment.

(xiv) Supply and transportation of material and construction of substation equipment foundations.

(xv) Supply, transportation and installation of substation outdoor equipment support structure steelworks, including new feeder switch structures inside the substation yard.

(xvi) Supply, transportation and installation of feeder switches, complete with surge arresters, operating rods and handles.

(xvii) Supply, transportation, and installation of OHTE feed-in structures over the two Up / Down South Coast railway lines as well as over the two Up / Down Reunion railway lines, passing the substation.

(xviii) Supply, transportation and installation of substation yard lighting and lightning masts.

(xix) Supply, transportation and installation of feeder cables between the 3kV DC HSCBs and the OHTE feeder switch structures including associated hardware/fittings.

(xx) Supply, transportation and installation of new 6.6kV AC power cables between the substation negative return manhole and the negative return busbar.

(xxi) Supply, transportation and installation of a new negative return manhole and bonds from the track return rails to the negative return manhole busbar.

(xxii) Lifting the existing perimeter security fence and gate to suit new platform level.

(xxiii) Supply, transportation and installation of internal fences and gates complete.

(xxiv) Supply, transportation and installation of kerbing around the perimeter fencing of the substation.

(xxv) Supply, transportation and installation of the substation protection scheme.

(xxvi) Supply, transportation and installation of all interfacing equipment/cables for tele-control equipment.

(xxvii) Supply, transportation and installation of equipment for the AC and DC auxiliary supplies.

(xxviii) Supply, transportation and installation of a new SIS500 tele-control outstation.

(xxix) Supply, transportation and installation of substation yard crusher stones after application of an environmentally approved weed killer for local conditions.

(xxx) Supply, transportation and installation of an intruder alarm system.

(xxxi) Supply, transportation and installation of a fire protection system.

(xxxii) Supply, and installation of substation labels, danger warning signs and name boards.

(xxxiii) Perform factory and site acceptance testing.

(xxxiv) Calibration of protection relays based on the calculated protection settings.

(xxxv) Do pre- commissioning and final commissioning testing of the new installation.

e) After the Employer is satisfied with the new installation and completion of all commissioning and testing, energise the new assets into service.

f) All relevant test, commissioning, maintenance, operational, training etc. documentation as well as relevant training shall form part of the Works.

g) Any other work arising from or incidental to the above or required from the Contractor for the proper completion of the Works in accordance with the true meaning and intent of the Contract documents.

4 PHASE WORKING

a) The substation is currently operational and disruption to the service shall be kept to a minimum. In order to achieve this, the refurbishment of the substation shall be executed in two phases.

4.1 Phase 1 of Refurbishment

a) In phase 1, the substation shall be operated as a tie-station while the rest of the substation shall be refurbished.

b) The equipment described below shall remain operational during phase 1.

1) All the equipment inside the existing HSCB house. This include the HSCBs, battery charger and batteries and tele-control equipment.

2) Feeder cables to the OHTE switch structures next to the track on the north western side of the substation.

3) Feeder switch structures inside the substation yard (6 x feeder switches on the UC steel masts).

c) The remainder of the equipment in the substation yard shall be decommissioned and removed from site.

d) The equipment in the remaining two buildings shall be decommissioned and removed from site.

e) These two buildings shall be demolished and all rubble removed from site.

f) Set out and construct layer works for the new substation platform.

g) Construction of the new substation building.

h) The Contractor shall supply, install and commission a 50kVA 6.6kV/400V temporary LV step-down supply point for the duration of the Phase 1. See clause 5 for details regarding the temporary Works.

i) Installation and testing of all equipment inside the new substation.

4.2 Phase 2 of Refurbishment

a) In Phase 2, the substation will be off-line until completion of the Works.

b) All the remaining old substation equipment used during phase 1 shall be decommissioned / demolished and removed from site. This include the following:

1) Equipment inside the HSCB House as well as the building itself.

2) The existing feeder cables to the OHTE switch structures next to the track at the substation.

3) The 6 x feeder switch masts, including their foundations, inside the substation yard.

c) The two new switch structures (structure no.1 and no.2) in the substation yard shall be constructed and all equipment installed on them.

(i) The existing 6 x aerial feeders to the OHTE will remain and be connected to the new feeder switches.

(ii) Should the existing 6 x feeder conductors be of inadequate length to connect to the new feeder switches on switch structure no.2, the Contractor shall extend the conductors by splicing in a length of the same conductor.

d) Removal of the temporary LV power supply step-down point, isolation transformer and related equipment. The equipment that will be removed shall be transported to the Durban Electrical depot for re-use.

e) Final testing, commissioning, energising and handover shall be done at the end of this phase.

5 TEMPORARY WORKS

a) The Contractor shall supply, install and commission a temporary LV supply for the auxiliary equipment in the HSCB House for the duration of Phase 1 of the refurbishment.

1) The temporary supply shall consist of a 6.6kV/400V LV step-down point, an isolation transformer (1:1 ratio), as well as cabling and wiring.

2) The step-down point shall include one 50kVA, 6.6kV/400V, 3-phase AC, 50Hz pole mounted transformer.

3) The transformer shall be suitable for mounting on an OHTE type mast. The transformer shall be manufactured in compliance with SANS 780.

4) The transformer shall have bushings on the primary as well as on the secondary side.

5) The OHTE mast and foundation shall be supplied and installed by the Contractor. The mast shall have an overturning moment strength of 85kN.m or higher.

6) The step-down point shall be constructed on the opposite side of the tracks on the north western side of the substation. The exact position will be determined on site.

7) The primary side of the transformer shall be connected to the existing PRASA 6.6kV distribution line on the north western side of the substation.

8) The transformer shall be protected against overloads by 6.6kV AC drop-out fuses.

9) 6.6kV MV surge arresters shall protect the transformer against lightning currents and surge voltages.

10) The secondary side of the step-down transformer shall be connected to the primary of the isolation transformer in the HSCB House with a 4-core LV armoured cable.

11) The LV supply cable from the step-down transformer secondary shall be protected by a LV withdrawable moulded case circuit breaker. The withdrawable circuit breaker shall be installed in a weatherproof (IP55) stainless steel pole mounted lockable enclosure and mounted on the OHTE mast.

12) Earthing and bonding of the step-down structure forming part of the standby auxiliary transformer shall be in accordance with drawing CEE-PA-41

13) The Contractor shall supply and install the isolation transformer in the HSCB House as part of the temporary Works.

(i) The isolation transformer shall be used to separate the earthing system of the incoming external supply and the substation earth system.

(ii) The transformer shall be a 50kVA, 400V/400V, 3-phase AC, 50Hz transformer in accordance with specifications BBC 0330, BBB 8204 and BBB 5452.

(iii) The transformer shall have cable termination boxes on the primary as well as on the secondary side without any exposed live parts.

(iv) The insulation between the input winding and the output winding shall be able to withstand the rated power frequency test of 70kV AC specified for a system highest voltage of 36kV AC as specified in SANS 1019

(v) The transformer shall be able to withstand a test voltage of 22kV AC as specified in SANS 1019 for applied between the shorted output terminals and the input winding and tank for one minute

14) The secondary of the isolation transformer shall be connected to the LV equipment via a 3-pole circuit breaker in a suitable enclosure.

b) The Contractor shall supply and install a DC earth leakage busbar and relay in the HSCB House as part of the temporary work. Relay output shall be wired into the existing HSCB control panel to trip all the HSCBs when a 3kV DC earth fault is detected.

c) The 6.6kV step-down structure and equipment can only be constructed under permit conditions on the 6.6kV distribution line. The Contractor shall arrange with

PRASA for "Permits" on the 6.6kV line by applying to the Depot at least 6 weeks in advance.

d) Electrical permits can only be granted between 22:00 and 02:00 as well as one eight (8) hour permit per month on a Sunday during daytime hours.

e) Any other temporary work that might be required during the implementation of this project shall be the responsibility of the Contractor.

f) This includes any associated safety engineering and designs that may be required. Therefore, it is the responsibility of the Contractor to identify such additional temporary Works.

6 APPLICABLE STANDARDS

a) Except for Employer owned documents and standards, the Contractor shall obtain the latest versions/publications of these specifications and standards from their sources or publishers at own cost.

1) Unless otherwise specified all materials and equipment supplied shall comply with the current edition of the relevant SANS, BS and IEC publications where applicable.

b) Where reference is made to PRASA/TFR or Spoornet specifications, such documents will form part of the contract document for easy reference.

1) Any items offered in accordance with other standards will be considered at the sole discretion of the Employer. The Contractor shall be responsible to supply full details stating where the item offered differs from the specifications listed below as well as supplying a copy (in English) of the recognised standard specification(s) with which it complies.

c) The Contractor shall submit, as part of his/her tender a clause-by-clause statement of compliance on all the listed clauses of this document, as listed in schedule D.

6.1 General Standards

The general standards are listed in Table 1 below:

Document Number	Description
SANS 1921-6	Part 6: HIV/Aids awareness
SANS 1921-1	Part 1: General Engineering and Construction Works
SANS 1200AB	Section AB: Engineer's Office
SANS 1200A	Section A: General
RSR Act	Railway Safety Regulator Act 16 of 2002

Document Number	Description
OHS Act 85	Occupational Health and Safety Amendment Act, No.85 of 1993
OHS Act 6	Machinery and Occupational Safety Act, 1983 (Act 6 of 1983)
Act 107	National Environmental Management Act (Act 107 of 1997)

Table 1: List of General Standards

6.2 Building Standards

The building standards are listed in Table 2 below:

Document Number	Description
SANS 10400	The application of the National Building Regulations
SANS 791	uPVC pipes for underground non-pressure application
SANS 558	Boxes and manhole and inspection covers and frames
SANS 1200LC	Cable ducts
SANS 1200LB	Bedding (pipes)
SANS 1200GE	Pre-cast concrete (structural)
SANS 1200GB	Concrete (ordinary buildings)
SANS 1200G	Concrete (structural)
SANS 1200DB	Earthworks (pipe trenches)
SANS 1200DA	Earthworks (small works)
SANS 1200C	Site Clearance

Table 2: List of building standards

6.3 Electrical Standards

The electrical standards are listed in Table 3 below.

Document Number	Description
SANS 780	Distribution Transformers.
SANS 62305	Physical Damage to Structures and Life Hazard Protection Against Lightning Part 1, 2 And 3
SANS 62271-102	High-voltage switchgear and control gear Part 102: Alternating current disconnectors and earthing switches
SANS 62271-100	High-voltage switchgear and control gear Part 100: Alternating-current circuit breakers
SANS 60439-5	Low-voltage switchgear and control gear assemblies Part 5: Particular requirements for assemblies for power distribution in public networks

Document Number	Description
SANS 60439-4	Low-voltage switchgear and control gear assemblies Part 4: Particular requirements for assemblies for construction sites (ACS)
SANS 60439-3	Low-voltage switchgear and control gear assemblies Part 3: Particular requirements for low-voltage switchgear and control gear assemblies intended to be installed in places where unskilled persons have access for their use - Distribution boards
SANS 60439-2	Low-voltage switchgear and control gear assemblies Part 2: Particular requirements for busbar trunking systems (busways)
SANS 60439-1	Low-voltage switchgear and control gear assemblies Part 1: Type-tested and partially type-tested assemblies
SANS 60309-1	Plugs, Socket-outlets and couplers for industrial purposes (Part 1: General requirements)
SANS 60269-1	Low-voltage fuses – Part 1: General requirements
SANS 60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1 000 V
SANS 60137	Insulated Bushings for Alternating Voltages above 1000V
SANS 60099-4	Requirements for Metal Oxide Surge Arresters without Gaps for AC systems
SANS 60076-7	Power transformers Part 7: Loading guide for oil-immersed power transformers
SANS 60076-5	Power transformers Part 5: Ability to withstand short circuit
SANS 60076-4	Power transformers Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
SANS 60076-3	Power transformers Part 3: Insulation levels, dielectric tests and external clearances in air
SANS 60076-2	Power transformers Part 2: Temperature rise for liquid-immersed transformers
SANS 60076-1	Power Transformers
SANS 60060-1	High-voltage test techniques Part 1: General definitions and test requirements
SANS 60056	High Voltage alternating current circuit-breakers
SANS 60044-2	Instrument transformers Part 2: Inductive voltage transformers
SANS 60044-1	Instrument transformers Part 1: Current transformers
SANS 555	Unused and Reclaimed Mineral Insulating Oils for Transformers and Switchgear (Uninhibited).
SANS 529	Heat resisting wiring cables

Document Number	Description
SANS 50054-7	Fire detection and fire alarm systems Part 7: Smoke detectors – Point detectors using scattered light, transmitted light or ionisation
SANS 50054-5	Fire detection and fire alarm systems Part 5: Heat detectors – Point detectors
SANS 1799	Watt-hour meters – AC electronic meters for active energy
SANS 1777	Photoelectric control units for lighting (PECU's)
SANS 1765	Low Voltage switchgear and control gear assemblies (distribution boards) with a rated-short circuit withstand strength up to and including 10kA
SANS 1619	Small power distribution units (ready boards)
SANS 1574	Electric Flexible Cores, Cords and Cables with Solid Extruded Dielectric Insulation
SANS 156	Moulded Case Circuit Breakers
SANS 164-2	Plug and socket-outlet systems for household and similar purposes for use in South Africa Part 2.
SANS 1507	Electric Cables with Extruded Solid Dielectric Insulation for Fixed Installations (300/500V to 1900/3300V)
SANS 1433-2	Electrical terminals and connectors – Part 2: Flat push-on connectors
SANS 1433-1	Electrical terminals and connectors – Part 1: Terminal blocks having screw and screwless terminals
SANS 1411-1	Materials of insulated electric cables and flexible cords – Part 1: conductors
SANS 1239	Plugs, socket-outlets and couplers for industrial purposes
SANS 1213	Mechanical cable glands
SANS 1195	Busbars
SANS 1063	Earth rods and couplers
SANS 10389-2	Exterior Security Lighting
SANS 10313	Protection Against Lightning - Physical Damage to Structures and Life Hazard.
SANS 10222-5-1-3	Electrical security installations Part 5-1-3: CCTV installations - CCTV surveillance systems for use in security applications - Installation, planning and implementation requirements
SANS 10222-2-7	Access Control Systems: Barriers
SANS 10222-2-2	Access Control
SANS 10222-2-1	Access Control Systems: General Requirements
SANS 10222-1-7	Intruder Alarms: Power Units
SANS 10222-1-5	Intruder Alarms Systems, Passive Infra-Red Detectors

Document Number	Description
SANS 10222-1-2	Intruder Alarms Systems, Infra-red Beam Interruption Detectors
SANS 10222-1-1	Electrical security systems Part 1-1: Intruder alarm systems - General requirements
SANS 10199	The Design and Installation of Earth Electrodes
SANS 1019	Standard Voltages, Currents and Insulation Levels for Electricity Supply
SANS 10142-1	The Wiring of Premises Part 1: Low-Voltage Installations
SANS 10142-2	The wiring of premises Part 2: Medium-voltage installations above 1 kV AC not exceeding 22 kV AC and up to and including 3 000 kW installed capacity

Table 3: List of electrical standards

6.4 IEC Standards

The IEC standards are listed in Table 4 below.

Document Number	Description
IEC62271	Specification for AC metal enclosed switchgear and control gear, for voltages above 1kV up to and including 52kV
IEC60297-1:	Dimensions of mechanical structures
IEC TR 62271-310	High-voltage switchgear and control gear - Electrical endurance testing for circuit
IEC 62271-308	High-voltage switchgear and control gear - Guide to Asymmetrical short circuit breaking
IEC 62271-203	High-voltage switchgear and control gear - Gas-insulated metal-enclosed switchgear
IEC 62271-200	High-voltage switchgear and control gear - AC metal-enclosed switchgear and control gear
IEC 62271-105	High-voltage switchgear and control gear - Alternating-current Switch Fuse Combination
IEC 62271-102	High-voltage switchgear and control gear - High-voltage alternating-current Disconnect
IEC 62271-100	High-Voltage Switchgear and Control Gear: Alternating Current Circuit Breakers.
IEC 61869-2	Instrument Transformers - Part 2: Current Transformers.
IEC 61869	Instrument Transformers: Additional General Requirements for Low Power Instrument Transformers.

Document Number	Description
IEC 60947-7-1	Low-voltage switchgear and control gear - Ancillary equipment - Terminal blocks for copper conductors
IEC 60947-6-2	Low-voltage switchgear and control gear - Multiple function equipment - Control and protective switching devices for equipment
IEC 60947-6-1	Low-voltage switchgear and control gear - Multiple function equipment - Automatic transformer/Transfer switching equipment
IEC 60947-4-3	Low-voltage switchgear and control gear - Contactors and motor-starters - AC semiconductor controllers and contactors for non-motor loads
IEC 60947-4-2	Low-voltage switchgear and control gear - Contactors and Motor Starters - AC Semiconductor motor controllers and starters
IEC 60947-4-1	Low-voltage switchgear and control gear – Electromechanical Contactors and Motor Starters
IEC 60947-3	Low-voltage switchgear and control gear - Switches, disconnectors, switch disconnector
IEC 60947-2	Low-voltage switchgear and control gear - Circuit Breakers
IEC 60947-1	Low-voltage switchgear and control gear - General rules
IEC 60815:	Guide for the selection of insulators in respect of polluted conditions.
IEC 60730-2-9.	Automatic electrical controls for household and similar use Part 2-9: Particular requirements for temperature sensing controls
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60502-4	Power cables with extruded insulation and their accessories for rated voltages
IEC 60502-2	Power cables with extruded insulation and their accessories for rated voltages
IEC 60502-1	Power cables with extruded insulation and their accessories for rated voltages
IEC 60298	AC metal-enclosed switchgear and control gear for rated voltages above 1kV and up to and including 52kV.
IEC 60296	Fluids for Electrotechnical Applications - Unused Mineral Insulating Oils for Transformers and Switchgear.
IEC 60255-5	Electrical Relays - Insulation Coordination for Measuring Relays and Protective Equipment- Requirements and Tests.
IEC 60255-22	Measuring Relays and Protection Equipment - Part 22-5: Electrical Disturbance Tests - Surge Immunity Test.

Document Number	Description
IEC 60255-121	Measuring Relays and Protection Equipment - Part 121: Functional Requirements for Distance Protection.
IEC 60255-11	Measuring Relays and Protection Equipment - Part 11: Voltage Dips, Short Interruptions, Variations and Ripple on Auxiliary Power Supply Port.
IEC 60255-1	Measuring Relays and Protection Equipment - Part 1: Common Requirements.
IEC 60099-4	Surge Arresters - Part 4: Metal-Oxide Surge Arresters without Gaps for AC Systems.
IEC 60092-352	Choice & Installation of Cables for Low Voltage Power Systems
IEC 60092_376	Cable for Control & Instrumentation Circuits
IEC 60092_375	General Instrumentation, Control & Communication Cables
IEC 60076-8	Power transformers - Application guide
IEC 60076-7	Power transformers Part 7: Loading guide for oil-immersed power transformers
IEC 60076-5	Power transformers - Ability to withstand short circuit
IEC 60076-4	Power transformers - Guide to the lightning impulse and switching impulse testing
IEC 60076-3	Power transformers - Insulation levels, dielectric tests and external clearances in air
IEC 60076-2	Power transformers - Temperature rise
IEC 60076-10	Power transformers - Determination of sound levels
IEC 60076-1	Power transformers – General
IEC 60051-1	Direct Acting Indicating Analogue Electrical Measuring Instruments and their Accessories - Part 1: Definitions and General Requirements Common to all Parts.
IEC 60044-4:	Instrument transformers – Part 4: Measurement of partial discharge
IEC 60044-2:	Instrument transformers- Part 2: Inductive voltage transformers

Table 4: List of IEC standards

6.5 Building Management and Energy Efficiency Standards

The building management and energy efficiency standards are listed in Table 5 below.

Document Number	Description
SANS 941	Energy efficiency of electrical and electronic apparatus
SANS 50285	Energy efficiency of electric lamps for household use - Measurement methods
SANS 50001	Energy management systems - Requirements with guidance for use
SANS 204-3	Energy efficiency in buildings Part 3: The application of the energy efficiency requirements for buildings with artificial ventilation or air conditioning
SANS 204-2	Energy efficiency in buildings Part 2: The application of the energy efficiency requirements for buildings with natural environmental control
SANS 204-1	Energy efficiency in buildings Part 1: General requirements
SANS 204	Energy efficiency in buildings
SANS 10400-XA	The application of the National Building Regulations (Part X: Environmental sustainability Part XA: Energy usage in buildings)

Table 5: List of building management and energy efficiency standards

6.6 Environmental Standards

The environmental standards are listed in Table 6 below.

Document Number	Description
SANS 61753-2-1	Fibre optic interconnecting devices and passive components performance standard Part 2-1: Fibre optic connectors terminated on single-mode fibre for category U - Uncontrolled environment
SANS 61000-6-5	Electromagnetic compatibility (EMC) Part 6-5: Generic standards - Immunity for power station and substation environments
SANS 61000-2-3	Electromagnetic compatibility (EMC) Part 2: Environment Section 3: Description of the environment - Radiated and non-network-frequency-related conducted phenomena
SANS 61000-2-2	Electromagnetic compatibility (EMC) Part 2-2: Environment - Compatibility levels for low frequency conducted disturbances and signalling in public low voltage power supply systems
SANS 60793-1-5	Optical fibres Part 1: Generic specification Section 5: Measuring methods for environmental characteristics
SANS 300132-3	Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment Part 3: Operated by rectified current source, alternating current source or direct current source up to 400V

Document Number	Description
SANS 300132-2	Environmental Engineering (EE); Power supply interface at the input to telecommunications equipment Part 2: Operated by direct current (dc)
SANS 23045	Building environment design - Guidelines to assess energy efficiency of new buildings
SANS 1760	Land mobile communication equipment - Technical characteristics and additional requirements of environmental tests
SANS 16818	Building environment design - Energy efficiency - Terminology
SANS 1574-2	Electric flexible cables with solid extruded dielectric insulation Part 2: PVC insulated flexible cables for domestic, office and similar environments (cords)

Table 6: List of environmental standards

6.7 Steel Structures Standards

The steel structures standards are listed in Table 7 below.

Document Number	Description
SANS 62262	Degrees of Protection Provided by Enclosures for Electrical Equipment against External Mechanical Impacts (IK Code).
SANS 62208	Empty Enclosures for Low-Voltage Switchgear and Control Gear Assemblies- General Requirements.
SANS 61439-2	Low-voltage switchgear and control gear assemblies Part 2: Power switchgear and control gear assemblies
SANS 60670	Boxes and Enclosures for Electrical Accessories for Household and Similar Fixed Electrical Installations Part 1: General Requirements.
SANS 60529	Degrees of Protection Provided by Enclosures (IP Code).
SANS 50025-6	Replacement of SANS 1431, Hot rolled products of structural steels Part 6: Technical delivery conditions for flat products of high yield strength structural steels in the quenched and tempered condition.
SANS 50025-5	Replacement of SANS 1431, Hot rolled products of structural steels Part 5: Technical delivery conditions for structural steels with improved atmospheric corrosion resistance.
SANS 50025-4	Replacement of SANS 1431, Hot rolled products of structural steels Part 4: Technical delivery conditions for thermo-mechanical rolled weld-able fine grain structural steels.

Document Number	Description
SANS 50025-3	Hot Rolled Products of Structural Steels Part 3: Technical Delivery Conditions for Normalized Rolled Weldable Fine Grain Structural Steels.
SANS 50025-2	Replacement of SANS 1431, Hot rolled products of structural steels Part 2: Technical delivery conditions for non-alloy structural steels.
SANS 50025-1	Replacement of SANS 1431, Hot rolled products of structural steels Part 1: General technical delivery conditions.
SANS 50025	Hot Rolled Products of Structural Steels.
SANS 2063	Thermal Spraying - Metallic and other Inorganic Coatings - Zinc, Aluminium and their Alloys.
SANS 2001	Construction Works Part CS1: Structural Steelwork.
SANS 1274	Coatings Applied by the Powder-Coating Process.
SANS 121	Hot Dip Galvanized Coatings on Fabricated Iron and Steel Articles - Specifications and Test Methods.
SANS 1200H	Structural Steelwork.
SANS 1200 HC	Standardized Specification for Civil Engineering Construction Section HC: Corrosion Protection of Structural Steelwork.
SANS 1200 HA	Standardized Specification for Civil Engineering Construction Section HA: Structural Steelwork (Sundry Items).
SANS 1186	Symbolic safety signs Part 1: Standard signs and general requirements.
SANS 1091	National Colour Standard.

Table 7: List of steel structure standards

6.8 National Rationalised Specifications (NRS)

The NRS standards are listed in Table 8 below.

Document Number	Description
NRS 048-2	Electrical supply – Quality of supply Part 2.
NRS 030	Electromagnetic voltage transformers for rated AC voltages from 3,6kV up to and including 145kV.

Table 8: List of NRS standards

6.9 BS Standards

The BS standards are listed in Table 9 below.

Document Number	Description
BS2692-1	Fuses for Voltages Exceeding 1000V AC
BS EN 62271-100	AC Circuit Breakers of Rated Voltage above 1kV
BS EN 61439-2:2011	Low-voltage switchgear and control gear assemblies. Power switchgear and control gear assemblies
BS EN 60730	Electrical Controls for Domestic Appliances
BS EN 60099-1	Surge Diverters for Alternating Current Systems
BS EN 60044-1	Current Transformers.
BS 7354	Code of Practice for design of high voltage open-terminal stations
BS 5486-1	Specification for factory-built assemblies of switchgear and control gear for voltages up to and including 1000V AC and 1200V DC
BS 159	Busbars and Busbar Connections

Table 9: List of BS standards

7 TFR/PRASA SPECIFICATIONS

The schedule of applicable specifications, Generic Test Sheets and Engineering Instructions as may be applicable is attached as Schedule B: Schedule of Specifications to this SoW.

7.1 Specifications for Substation Equipment

a) These specifications are generic in nature and might refer to other projects and the references to those projects should be disregarded. However, the technical requirements of the equipment shall be applicable.

b) Although these are mostly TFR specifications, to a certain degree, similar technology and some aspect of operational philosophy is shared with PRASA.

c) The Contractor shall ensure that he is in possession of and use the latest versions of these specifications.

7.2 Generic Test Sheets, Certificates and Reports

a) The information provided on the test sheets might not all be relevant to the Works, but they provide the Contractor with an example of the type of documents required during the testing and commissioning process.

b) Therefore, these shall only be used for information purposes and the Contractor shall develop his own test sheets for this project.

c) The Contractor shall be responsible to submit his developed test sheets to the Employer for acceptance at the same time as providing equipment designs.

d) Approved test sheets shall be made available by the Contractor before the commencement of any SAT and functional testing.

e) The Contractor shall further submit all the planned FAT sheets for equipment to be tested.

7.3 Technical Requirements and Returnables

a) The sheets to be completed with technical details of specific equipment offered and returned as part of this submission are attached as Schedule C: Schedule of Equipment Data Sheets, for ease of reference.

b) The SoW Clause-by-Clause statement of compliance is attached as Schedule D and will be used as part of the technical evaluation.

c) The Supplier/Manufacturer/Plant Information is attached as Schedule E for Tenderer's declaration.

d) The information on staff available is attached as Schedule F and will be used as part of the tender evaluation process.

e) The declaration of Sub-Contractors proposed by the Tenderers is attached as Schedule G.

8 ENGINEERING

8.1 Accepted Employer's Design

All the Employer's drawings are attached as Schedule A: Schedule of Drawings.

8.2 Design Brief and Deliverables

a) The Contractor shall review the Employer's designs and prepare detailed designs (shop drawings) incorporating the minimum specifications including but not limited to the specific items listed below: -

1) Fully functional double unit traction substation incorporating both power plant and control plant equipment.

2) All equipment shall be adequately earthed, insulated, enclosed and interlocked to ensure the safety of staff (operators) as well as equipment.

3) Fault Level calculations.

4) Protection setting calculations and configuration.

5) SIS500 tele-control outstation and telecommunications panel.

6) Interfacing with the OHTE.

7) Temporary Works.

b) The Contractor's design work (shop drawings), for the complete substation shall include the power plant and the control plant with an accompanying operating philosophy report, installation, testing, and commissioning of 3kV DC double unit traction substation.

c) The Contractor's design will be reviewed, and non-conformances will be communicated to the Contractor for rectification / amendment before the design will be accepted by the Client.

1) The detailed fault level calculations and protection settings shall also be submitted to the Client for review and comments

8.3 Service Conditions

The equipment shall be designed and rated for operation under the service conditions give in Table 10 below: -

Description	Criteria
Altitude	0 To 1 800m Above Sea Level
Ambient Temperature Range	Minus 5 °C to Plus 50 °C
Relative Humidity	10% To 90% non-condensing
Atmosphere	Heavy polluted environment; salt laden, industrial and locomotive fumes and severe dust conditions
Wind Pressure on Equivalent Projected Area Normal to Direction of Wind	750Pa
Lightning Conditions	5 Flash / km² / Annum

Table 10: Service conditions

8.4 Insulation Levels

a) The insulation levels for the equipment shall be in accordance with the recommendations of SANS 1019.

b) The insulation level for 3kV DC shall be based on 6.6kV AC nominal system voltage insulation requirements.

The power equipment (voltages phase to phase RMS) shall have a rated insulation level based on an equivalent 3-phase system as indicated in Table 11 below.

Nominal System Voltage	6.6kV	11kV	22kV	33kV
Highest System Voltage for Equipment	7.2kV	12kV	24kV	36kV
Rated Lightning Impulse Withstand Voltage for 50 µs	75kV	95kV	150kV	200kV
Rated Power-Frequency Withstand Voltage for 60 Sec	22kV	28kV	50kV	70kV

Table 11: Insulation levels

8.5 Clearances

Table 12 indicates the minimum earth clearances that shall be maintained between any conductor or metal normally alive and earthed metal.

Nominal System Voltage	6.6kV	11kV	33kV	33kV
Minimum Safety Clearance	150mm	200mm	320mm	430mm

Table 12: Minimum earth clearances

Table 13 indicates the minimum safety clearances that shall be adhered to between any conductor or metal normally alive and ground surface level.

Nominal System Voltage	6.6kV	11kV	22kV	33kV
Restricted Access Way (Vertical Height)	3150mm	3200mm	3320mm	3430mm
Outside Security Fence	5500mm	5500mm	5500mm	5500mm

Table 13: Minimum safety clearances

8.6 Creepage Distance

a) The insulators or bushings provided on all medium voltage transformers shall comply with the requirements of SANS 60137.

The equipment shall have a creepage distance based on Table 14 below.

Nominal System Voltage	6.6kV	11kV	22kV	33kV
Highest Voltage for Equipment	7.2kV	12kV	24kV	36kV
Heavy Pollution	31mm/kV	31mm/kV	31mm/kV	31mm/kV

Table 14: Creepage distances

8.7 Corrosion Protection

All steelwork for outdoor installation shall be hot-dipped galvanised to SANS 121. Steelwork shall be painted in accordance with specification CEE.0045 after galvanising.

8.7.1 Preparation of Steel

a) Where it is impractical to galvanise large areas of sheet steel, surfaces for outdoor exposure in coastal areas shall be prepared in accordance with specification CEE.0045.

b) The Contractor shall advise the Employer of any large sheet steel areas which he intends not to galvanise, for both parties to agree on such material before construction starts.

c) The Contractor shall cover any material he deems not to be galvanised in his covering letter with proof that it is impractical to have such material galvanised.

8.7.2 Handling and Final Treatment of Painted Steelwork

a) Painted steel shall be handled with care and/or suitably packed to avoid damage during transportation and installation.

b) Any damage to painted surfaces shall be repaired after installation, after which a final finish coat of the paint specified in specification CEE.0045 shall be applied.

Table 15 specifies the colours to be used for outdoor equipment.

Item No.	Description	Colours Description
1	Coastal structural support steel	Tower Grey
2	Traction transformer tank	G12
3	Traction transformer conservator tank	White
4	All outdoor enclosures	G12

Table 15: Outdoor equipment colours

Table 16 specifies the colours to be used for indoor equipment.

Item No.	Description	Colours Description
1	11kV Metal Clad Switchgear Panels	Light Orange B26
2	3kV DC Indoor panels and enclosures	Eau-de-Nil NH 43

Table 16: Indoor equipment colours

9 SUBSTATION EQUIPMENT AND SERVICES

9.1 Outdoor Equipment

9.1.1 Traction Transformers

a) Further to clause 14.0 of specification BBB5452, the Contractor shall design, supply and install two 10.1MVA Traction Transformers.

b) The design of the traction transformers shall generally be in accordance with specifications BBF 9997 and BBB 5452.

c) The vector-group configurations of the transformers shall be as depicted in **Error! Reference source not found.** in order to achieve 12-pulse rectification on the 3kV DC busbar for this double unit traction substation.

d) Each transformer shall be supplied with a 100kVA tertiary winding to supply power to the 100kVA auxiliary transformers.

Table 17 below specifies the transformer configuration and vector group.

Winding	Power (MVA)	Voltage (kV)	Group	Tap Changer
High Voltage Primary	10.1	11 ± 2 x 2.5%	Y	Off-load
Medium Voltage Secondary	2 x 5	1.220 / 1.220	d / d with 15° Phase shift	-
Tertiary	0.1	2.360	yn	-
Vector Group		Ydd.yn0		

Table 17: Rectifier transformer configuration for 12 pulse rectification

e) The Contractor shall ensure that the new transformer oil supplied complies with SANS 555 and the oil shall be tested before being put into the transformers.

f) The transformers shall have cable terminations on the primary sides and MV bushings on the secondary sides. The primary cable terminations shall be inside a lockable cable termination box.

g) The terminations for the tertiary windings shall also be inside a lockable cable termination box for connections by cable. The protection CTs for the MV cable and main auxiliary transformer shall be installed in the cable termination box.

h) The transformer Buchholz relay shall have test switches for alarm and trip function.

i) The transformer shall be installed with an on-line dissolved gas analyser.

9.1.2 Auxiliary Transformers

a) The Contractor shall supply and install two 100kVA, 2.36kV/400V, 3-phase AC, 50Hz auxiliary transformer partly in accordance with specifications BBB 8204 and BBB 5452. The vector group of the transformers shall be Dyn11.

b) The transformers shall supply LV auxiliary AC power to the auxiliary equipment in the substation

c) The primary side of the auxiliary transformers shall be connected to the 2.36kV tertiary windings of the traction transformers.

d) Protection of the auxiliary transformers shall be by protection relays installed in the primary circuit breaker control panels. The protection CTs shall be installed inside the cable termination box for the tertiary windings, as part of the manufacturing of the traction transformers.

e) Further to clause 15.7 of specification BBB 5452, the auxiliary transformers shall have cable termination boxes for connections of MV and LV cables on the primary as well as on the secondary side respectively, having no exposed live parts.

f) The LV supply cables from the transformers' secondary windings shall be protected by LV withdrawable circuit breakers. The withdrawable circuit breakers shall be installed in lockable steel powder coated enclosures on the plinths next to the transformers.

g) The output of the standby auxiliary transformers can be subjected to 3kV DC under fault conditions and requires to be insulated to reduce the risk of damage caused by these over voltages.

h) The insulation between the input winding and the output winding shall be able to withstand the rated power frequency test of 22kV AC specified for a system highest voltage of 7.2kV AC as specified in SANS 1019.

i) The output winding terminals (400V) shall be insulated for medium voltage.

j) The transformers shall be able to withstand a test voltage of 22kV AC as specified in SANS 1019 applied between the shorted output terminals and the input winding and tank for one minute.

9.1.3 Track Feeder Switch structures

a) The Contractor shall supply and install two track feeder switch structures (no.1 and no.2) including the hand operated feeder switches complete with handles and push rods as shown on the drawings CEE-TMG-098 and on the Employer's design drawings listed in Schedule A.

b) Capacitors and 3kV DC surge arresters shall be supplied and installed as part of the feeder switch for protection of equipment against voltage and current surges.

1) The capacitor shall be connected between the feeder cable side of the track feeder switch and the steelwork of the switch structure.

2) The surge arrester shall be connected between the OHTE aerial feeder side of the track feeder switch and the earth spike which shall be connected to the main earth mat.

c) Spark gap type gas filled arresters shall be supplied and installed on the masts of the new switch structures. The terminals of the spark gaps shall be bonded to the masts they are mounted on and the earth down leads of the 3kV DC surge arresters using a suitable T-crimp connector.

d) Each switch structure shall be bonded to the tracks or negative return busbar with two separate 96mm² stranded galvanised steel insulated bonds.

9.2 Building Indoor Equipment

9.2.1 11kV AC MV Indoor Metal Clad Switchgear

a) The Contractor shall supply and install indoor MV withdrawable (AIS) vacuum circuit breakers in accordance with specification BBB 4182.

b) Should there be any discrepancies between the requirements of specification BBB4182 and the Employer's design drawings, the design drawings shall take precedence.

c) The circuit breaker arrangements shall be as indicated on the single line and protection diagram of the Employer's design shown on the drawings listed in Schedule A.

d) A set of 11kV surge arresters shall be supplied and installed in the enclosures of each of the two incoming supply circuit breakers, in accordance with specifications BBB 0845, BBB 5452 and SANS 60099-4.

1) The surge arresters shall protect the equipment against lightning currents and surge voltages on the incoming supply side

e) The MV circuit breakers shall trip and remain open (operational inhibit) should the circuit breaker's tripping power supply (110V DC) be lost completely or fall below 70% of nominal battery voltage.

f) It shall only be possible to close the circuit breakers when the supply voltage reaches 85% of the nominal value

g) The two 11kV incoming supplies from the municipality may never be connected to each other. Interlocking between the two incoming supply circuit breakers and the 11kV busbar circuit breaker coupler shall be provided such that a maximum of only two of the three circuit breakers can be closed at any one time.

h) The two primary circuit breakers shall each be controlled from separate rectifier unit protection control panels situated inside the substation control building.

i) The primary circuit breaker enclosures shall each incorporate an earth switch which shall earth the load side (traction transformer side) of that particular circuit breaker when the circuit breaker is withdrawn from the enclosure

j) The Contractor shall supply and install one set of 11kV AC busbar voltage transformers as per NRS 030, IEC 60044-2 on each of the 11kV busbar sections.

1) The ratings and installation of the voltage transformers shall be as indicated on the single line and protection diagrams.

2) The output of the voltage transformers shall be used for energy metering purposes, power quality monitoring, and for the phase failure detection system on the incoming MV supply.

k) The Contractor shall supply and install current transformers as per IEC 60044-1 in each of the switchgear enclosures for protection and / or measuring purposes.

1) Metering and protection cores shall be provided. The number of cores and their ratios are shown on the substation single line diagram and protection diagrams.

l) The Contractor shall further supply and install summation CTs in order to measure the total substation energy consumption.

9.2.2 3kV DC Rectifiers

a) Further to specifications BBF 9986 and clause 18.0 of BBB 5452, the Contractor shall design, supply and install two 10MW AC to DC rectifiers to supply DC power to the overhead track equipment via the 3kV DC busbar and HSCBs.

b) The rectifiers shall provide for full wave 12 pulse rectification from the 6-phase output of the traction transformers.

c) The rectifiers shall be rated 10MW full load continuously. The overload characteristics of the rectifier shall be as per specification BBF 9986.

d) The rectifiers shall each be supplied complete with a diode monitoring system, cooling fan control and fully comply with TFR's specification BBF 9986.

e) All components, especially diodes, shall be easily accessible for maintenance and replacement purposes.

9.2.3 Reactor Coils

a) The Contractor shall supply and install two reactor coils, having an inductance of 1.8mH in accordance with specification BBB 3890 and clause 19 of specification BBB 5452.

b) Notwithstanding clause 6.4 of BBB 3890 the continuous current rating of the reactor coil shall be at least 3200A and the overloading to change accordingly.

9.2.4 Wave Filter Equipment

The Contractor shall supply and install wave filter equipment, for each rectifier unit, in accordance with TFRs specifications BBB 3139 for capacitors, BBB 3162 for inductors, clause 20.0 of specification BBB 5452 and drawing no. BBB 3483.

9.2.5 3kV DC Positive Isolators

a) The Contractor shall supply and install two positive isolator and earthing switches, in accordance with specifications BBB 4724 and clause 21 of installation specification BBB 5452.

b) The positive isolator switch shall have a minimum current rating of 4000A continuous as per clause 6.3 of specification BBB 4724.

c) The earthing switches shall have a minimum current rating of 1500A as per clause 6.10 of specification BBB 4724.

d) The MV compartments of the positive isolators shall include potential dividers for the under-voltage relays and fuses for metering as per clause 6.28 of specification BBB 4724.

e) The LV compartments shall accommodate the under-voltage relays, ammeters and voltmeters as per clause 6.21 of specification BBB 4724.

f) Access to the positive isolator enclosures shall only be possible from the back and side panels.

9.2.6 3kV DC Undervoltage Relays

a) The Contractor shall supply and install 3kV DC undervoltage relays in accordance with specification BBB 3005.

b) The under-voltage relays supplied shall fully comply with specification BBB 3005 and be installed with the potential divider as per clause 28.0 of specification BBB 5452.

c) Further to clause 6.1 of specification BBB 4724 and clause 28.6 of specification BBB 5452, the Contractor shall supply and install the under-voltage relays as part of the low voltage control gear of the positive isolator.

d) The potential dividers for the under-voltage relays shall be accommodated in the MV compartments of the positive isolators.

9.2.7 3kV DC High Speed Circuit Breakers and Cells

a) The Contractor shall supply and install 3kV DC Track Feeder High Speed Circuit Breakers in accordance with clauses 25 and 26 of specification BBB 5452 and specifications CEE.0099 and CEE.0227.

b) The Contractor shall supply and install the HSCB trucks, modular steel cells, circuit breakers, feeder protection relays and other associated components necessary to provide a complete functioning modular track breaker unit.

c) One HSCB will be used as a busbar coupler between the busbars of the two rectifier units. The remaining HSCBs will be used to protect `the different OHTE circuits.

d) Two separately enclosed 3kV DC busbar earthing switches shall be supplied and installed to individually earth the 3kV DC positive busbars to the negative return busbar.

e) These earthing switches shall be robust and lockable in both positions (earthed and not earthed).

f) The earthing contacts shall be visible through fixed polycarbonate panels in the enclosures to provide a visible view of the switch position.

g) Electrical interlocking shall be provided in the control circuits of the primary circuit breaker and all HSCBs to trip and lockout the substation when attempting to close the earthing switch whilst the 3kV DC busbar is still live. The interlocking shall also prevent the closing of any of the above circuit breakers whilst the earth switch is closed.

   1) The switch handles of the earth switches shall be inside the enclosures in order to prevent accidental movement of the switches. A limit switch shall be installed on the access panels to the earthing switches which shall be part of the interlocking system.

h) The shutter gear in the cells, covering the busbars when the circuit breaker is withdrawn, shall be robust and mechanically locked to prevent it from being opened while the truck is withdrawn from the cell.

i) Notwithstanding clause 25.3 and 25.4 of specification BBB 5452, the Contractor shall supply and install a DC Feeder Protection Relay, as per clause 9.2.8 of this document.

j) Notwithstanding clause 8.1.1 of specification CEE.0099, the continuous current rating of the High-Speed Circuit Breaker shall be 2600A for the outgoing circuits and 4000A for the busbar coupler.

9.2.8 DC Feeder Protection Relays

a) The relays are required to operate in conjunction with the 3 kV DC High Speed Circuit Breakers.

b) One relay per circuit breaker shall be supplied and installed as an integral part of the steel modular cell for each HSCB.

c) The Contractor shall ensure compatibility between the relay and circuit breaker and further ensure that the relay trip time command is the same as the HSCB fault trip coil.

d) The Contractor shall ensure that the engineering support and training on the relay is available locally in South Africa.

e) The Contractor shall provide a letter from the supplier as part of the bid confirming that the DC feeder protection relay is compatible with the particular HSCB offered and also the provision of a 2-year warranty commencing after the 1-year guarantee period.

f) The main functions of the relay to be used are: -

1) Protection of the overhead track equipment.

2) Automatic line test function to determine if any fault is present on the system before the circuit breaker is closed or to prevent auto reclosing onto a faulty OHTE circuit.

3) Overcurrent protection (I^2t and di/dt discrimination).

4) Undervoltage protection.

5) Frame fault protection.

6) Thermal protection of the Overhead Track.

7) Control of the circuit breaker.

8) Auto re-closure in the event of no fault on the system.

9) Auxiliary contacts.

10) Serial Communication port (RS232/RS485).

11) As a measurement/condition monitoring device on each track circuit.

12) Measure Current (DC)

13) Measure Voltage (DC)

14) Measure Energy kWh (Export and Import)

15) Counting all Energy operations (Condition Monitoring)

16) The relay shall operate from the 110 Volt DC substation battery supply.

g) The relay must be able to communicate with the receiver panel inside the substation via Bluetooth and Wi-Fi.

h) If resistors, potential dividers and current transducers are used in the design, the clearance and insulation levels for 3 kV DC must be adhered to.

i) The Contractor's attention is drawn to space restrictions.

9.2.9 Negative Return Monitoring System

a) The Contractor shall supply and install a negative return feeder monitoring system as per TFR's installation specification BBC 1843 and BBC 1844.

9.2.10 Regenerative High-Speed Circuit Breaker

a) Further to clause 27.0 of specification BBB 5452, no regenerative braking equipment will be required.

9.2.11 Battery Charger and Batteries

a) The Contractor shall supply, install and commission a battery charger and separate battery bank in accordance with specifications BBB 5452 and BBB 2502.

b) The battery charger panel shall be insulated from the substation floor by means of "Marley" or "Lino" floor covering or similar not less than 2mm thick

c) The batteries shall consist of a 53 cell 110 Volt Planté lead acid battery bank or similar approved.

d) The capacity of the battery shall be dependent on the substation requirements.

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

f) Batteries are installed in the traction substations to supply 110V to equipment for control and protection purposes. The battery is used for the following functions: -

1) Tripping and closing of primary circuit breakers.

2) Power supply to protection relays.

3) Closing and holding coil supply to DC high speed circuit breakers.

9.2.12 SIS500 Telecontrol Outstation Panel Interface

a) The Contractor shall design, supply and install all SIS500 telecontrol outstation and telemetering equipment according to specification BBC 0653.

b) The relay contacts provided in the telecontrol cabinet for remote operation of switchgear shall have a maximum rating of 0,5A at 110V DC.

c) Indication for telecontrol purposes shall be provided by means of voltage free open and closed contacts on the switchgear.

d) Provision shall be made for the following principal telecontrol operations indications and alarms: -

1) Open and close command function for all circuit breakers.
2) Open and close indication for all circuit breakers.
3) Lockout indication for all circuit breakers.
4) Indications of failure of DC feeder protection relay supply voltage. Detection must take place at each relay.
5) Indication of charger failure for DC control batteries.
6) Indication of transformer pressure relief device operation.
7) Door intruder alarm indication.
8) Alarms from the fire protection system
9) Holding coil supply indication
10) 3kV DC under voltage indication
11) 110V DC fail indication
12) DC earth leakage protection indication
13) Diode failure indication
14) 400V AC fail indication
15) Rectifier temperature indication
16) Incoming supply phase failure

e) Any additional telecontrol functions that might be necessary due to the supply and installation of any specialised equipment offered shall be provided by the Contractor.

f) The Contractor shall provide an event log/fault record date transmit through the telecontrol panel.

9.3 Control and Protection Equipment

9.3.1 General

a) The Contractor shall be responsible for the design, the ratings of all cabling, wiring, protection circuitry, sizing of contactors, relays, MCCB's, MCB's, isolators, fused isolators, fuse ratings, terminations and any other equipment and circuitry used.

b) In the event of a dispute, the Employer shall make the final decision on technical matters.

c) The Employer reserves the right to change the layout of any control and/or distribution panel to suit his requirements in terms of standardizing on panel layouts.

9.3.2 Panels

a) Panels shall comply with IEC60297-1. The following panels shall be supplied and installed in the substation control building: -

1) 11kV Primary circuit breaker control and protection panels.

2) AC/DC distribution panel Telecontrol outstation panel.

3) Battery charger panel.

4) Communications cabinet.

b) The new control and protection panels shall contain all the protective relays (IEDs) and circuit control equipment required for the operation of the associated breakers.

9.3.3 Primary Circuit Breaker Control and Protection Panel

a) The Contractor shall design, supply and install primary circuit breaker control panels in accordance with specification BBB 2721.

9.3.4 AC/DC Distribution Panel and Change-over Panel

a) The Contractor shall design, supply and install an AC/DC Distribution panel in accordance with specification BBB 2721.

b) The panel shall include an automatic change-over to select and connect one of the two available auxiliary supplies to the 400V LV 3-phase busbars inside the panel.

c) The change-over shall automatically disconnect the supply from the auxiliary transformer that is unavailable or off-line in case of power loss from that transformer and connect the alternative auxiliary transformer supply to the 400V 3-phase busbars.

d) Power supply protection relays shall be installed to monitor each auxiliary supply for phase failure, phase rotation as well as over and undervoltage for 400V AC

supply to the panels. The relays shall form part of the control circuit of the change-over system.

e) The Contractor shall submit details of the relay for acceptance by the Employer during the Contractor's design stage.

9.3.5 Panel Construction

a) The control and protective equipment shall be mounted on or within suitable panels constructed of sheet metal and fitted with front opening hinged doors all to allow for easy access to the equipment.

b) The steel sheeting shall not be less than 2mm thickness.

c) The panels shall be of rigid construction and fitted with lifting hooks.

d) The panels shall be of the swing frame type (access to the panel being via the front swing frame and having no rear access).

e) The panels shall be fitted with dummy interior covers to ensure that when components are mounted, no bolts or screws are visible on the exterior of the panel.

f) The panels shall be so constructed that control switches, indicating lamps, voltmeters and ammeters as well as LED type flag indication devices are visible without opening the hinged front doors.

g) The layout of the control equipment fitted on or in the panels, which includes relays, contactors, busbar, terminal strips etc. shall provide for easy access.

h) The panels shall be provided with 230V AC panel lights, which shall switch on only when the panel doors are open.

i) A three pin 16A industrial type switched socket outlet shall be installed inside the AC/DC panel for 230V AC supplies for hand tools.

j) Panel shall be fitted with gland plates, which will allow for cable entry from the bottom.

k) The installation Contractor shall punch all required holes into the gland plate on site. Spare holes shall be provided in the gland plates but sealed off with suitable sealing plugs.

l) All indoor panels shall be powder coated in accordance with SANS 1274.

m) The finishing colours shall be white gloss on the inside of the panels, and Eau-de-Nil H43 on the outside.

9.3.6 Protective Relays, Contactors, MCCB's, MCB's and Selector Switches

a) All contactors and relays shall be of liberal rating and design and of the sturdiest construction; they shall not be affected by vibration and shall be silent when energised.

b) Contacts shall be made of silver or other approved metal to minimise damage through oxidation and shall be designed to maintain good contact under all operating conditions.

c) Relays shall be completely sealed against the ingress of dust and dirt by means of non-flammable covers, which are easily removable.

d) The relays shall have a protection rating of IP34 as defined in IEC 60529.

e) All protection relays shall be housed in withdrawable pattern cases and shall be so designed and mounted as to make them free from failures due to equipment vibrations.

f) All protection relays shall comply with the requirements of specification IEC 60255.

g) All relays, contactors, links, MCCB's, MCB's and test terminals shall be readily accessible so that routine examination, maintenance and testing may be carried out without the need to remove bolted panels.

h) The control equipment provided shall be capable of correct operation within the voltage limits specified in IEC 62271-100.

i) In addition, the activation coils of all devices supplied from the substation auxiliary AC supplies shall be capable of satisfactorily operating under the harmonic voltage conditions encountered in a DC traction system.

j) All low voltage circuits in the panels shall be protected by suitably rated MCCBs or MCBs, which comply with SANS 156.

k) The circuit breakers shall have tripping characteristics of a C-curve design.

l) The MCB's shall isolate independent circuits from the bus wires.

m) All circuits supplied from the auxiliary transformers shall be protected by an earth leakage relay.

n) All 110V DC MCB's for supplying protection equipment shall be double pole ganged.

o) 110V DC operating relays shall be capable of satisfactory operation between 85 Volts and 140 Volts without any damage to the relays.

p) AC operated relays and contactors shall be suitably rated for the auxiliary supply voltage, which could vary due to the tapping range of the auxiliary transformers.

q) All circuitry shall be wired in the fail to safe mode i.e. relays and contactors must be de-energised under fault conditions.

r) A red mushroom head type (normally closed) emergency trip push button and switch shall be provided on the two primary circuit breaker control panels. When activated, the controls shall shut down and isolate the complete substation from all supplies by tripping the 11kV incoming circuit breakers primary circuit breaker as well as the 3kV DC HSCBs.

1) It shall not be possible to carry out any local and / or remote operations of the substation equipment until the push button and switch has been reset.

2) The button shall incorporate a turn-to-release action to reset ie. the push button and switch shall latch in the activated (contacts open) position and only release and reset when the head is turned.

s) No anti-condensation heaters are required in panels situated inside the traction substation building.

t) All circuit breakers, contactors, relays and indicating lamps shall be readily available on the open market.

u) Selector switches used for the DC voltmeter shall be of the make-before-break type.

9.3.7 Surge Protection

a) Surge protection devices shall be used for suitable protection of electronic equipment against over voltages, surges and transients.

b) Liberal use of metal oxide varistors is also encouraged.

c) Surge protection devices shall be provided for the 110V DC supply and shall be connected as follows:

1) One unit connected between the 110V DC Positive and Negative.

2) One unit connected between the 110V DC Positive and the panel earth.

3) One unit connected between the 110V DC Negative and the panel earth.

d) A 2-pole surge protection device shall be installed for the 230-volt AC supply to the control panels.

9.3.8 Electrical Measuring Instruments

a) The type of measuring instruments shall be readily available on the open market.

b) The details of instruments shall be marked with the ratio of the associated instrument transformers.

c) All analogue and digital electrical indication meters shall be in accordance with IEC 60051-1.

d) The meters shall be flush mounted in the panel doors. Analogue meters used for the measuring of AC and DC values shall have a class index of 1.5.

e) The analogue face of the meters shall not be less than 96mm x 96mm with a 90-degree display.

f) Digital meters used for the measuring of AC or DC values shall have a display of 3.5 digits, 12mm high and have an accuracy of 0.5%.

9.3.9 Wiring and Terminals

a) All wiring shall be carried out on the loop-in system and the looping-in shall be done at the terminal strips.

b) "X" type wiring will not be acceptable.

c) The method of loop wiring from one relay to another without protection for the individual circuits is not acceptable.

d) The cross-sectional area of all small conductors for low voltage circuits shall not be less than that required to ensure sufficient mechanical strength.

e) The conductors shall be of the multi-stranded type to ensure flexibility.

f) All wires and conductors for low voltage circuits shall be copper and a minimum of 2.5mm², except for the main battery supply cables between the main battery switch and busbar, which shall be at least 25mm².

g) The conductors for the multicore tele-control cable shall be at least 1.5mm² per conductor.

h) Provision shall be made for 10% spare conductors in the multicore tele-control cables supplied.

i) All wires and conductors shall be routed via PVC channel trunking with a removable cover.

j) Trunking of sufficient capacity to easily hold the conductors and wires shall be provided.

k) Conductor supports that are attached by adhesive are not acceptable.

l) Where low voltage busbars are mounted inside panels, they shall be mounted in such a manner as not to cause a hazard to maintenance staff working in the panels.

m) These busbars shall be covered with translucent polycarbonate barriers to prevent accidental contact with a live busbar. The barriers shall be provided with electric shock hazard warning signs.

n) Where equipment is mounted on the doors of the panels, adequate flexibility of the wiring shall be provided to eliminate any damage to the conductors.

o) The panels shall be provided with earthing studs for lugs of 95mm² earthing cables.

p) Sufficient terminal strips shall be provided for the number of outgoing / incoming circuits.

q) Terminals shall be provided near the bottom of the panels for the connection of cables from cable ducts in the floor of the building (Bottom entry).

r) The terminal strips shall be grouped together and arranged to facilitate the removal of connections.

s) Suitable terminal strips shall be provided to facilitate wiring from the various items of equipment to the remote-control station or telecontrol and local SCADA.

t) All panel doors shall be fitted with flexible braided earthing straps bolted to earthing studs on the doors and panels.

9.3.10 Labelling and Numbering

a) All terminals on equipment such as switches and relays shall be suitably numbered and reflected on the substation schematics and wiring diagrams.

b) All terminal blocks and groups of terminal blocks shall be suitably numbered.

c) All wires shall be provided with identification tags at terminals and shall be marked as reflected on the panel-wiring diagrams.

d) All cables shall be numbered and labelled at both ends with numbers the same as those which appear on the wiring schematics and diagrams.

e) All relays, cables, terminal strips, etc. which are mounted on panel doors shall be suitably labelled to clearly indicate their function.

1) Control switches, indicating lights, control push buttons, etc. which are mounted on the doors shall be suitably labelled on the inside and outside of the door to clearly indicate their function.

f) The labels shall be engraved with white lettering on a black background and permanently fixed with miniature screws or rivets.

g) Labels shall be fixed to the panel walls, support plates or doors. Labels shall not be fixed to components.

h) Each circuit breaker control panel shall be provided with labels to indicate the breaker designation and telecontrol code.

i) The Employer shall supply these designations and telecontrol codes to the Contractor.

j) All labels shall be in English.

k) The proposed labelling scheme shall be submitted to the Employer for acceptance prior to the manufacturing of the labels.

9.3.11 Protection Test Block

a) A PK2 test block shall be installed in the main overload protection circuits to enable the temporary connection of instruments, meters or test equipment without interfering with fixed wiring.

1) The test block shall be wired in between the terminals where the wires from the current transformers terminate in the panel and the overload protection relays.

b) A PK2 test block shall also be installed in the voltage transformer circuits to enable the temporary connection of instruments, meters or test equipment without interfering with fixed wiring.

c) The test block shall be wired in between the terminals where the wires from the voltage transformers terminate in the panel and the equipment.

d) Test blocks shall be fitted on the panel doors.

9.3.12 AC Earth Leakage Protection

a) The Contractor shall supply and install an AC earth leakage protection scheme in accordance with clauses 17.0 and 30.0 of specification BBB 5452 as well as section 8.5 of specification BBB 2721.

b) Notwithstanding the requirements of clause 17.1 of specification BBB 5452, the earth leakage CT shall be installed inside the 11kV switchgear room.

c) The protection system shall trip and lockout all the 11kV circuit breakers in the event of flashovers or earth leakage on the AC equipment.

d) This system shall serve the same purpose as frame leakage protection.

9.3.13 DC Earth Leakage and Cable Fault Protection

a) The Contractor shall supply and install DC earth leakage relay in accordance with clause 29.0 of specification BBB 5452 and section 8.6 of specification BBB 2721.

b) The DC earth leakage relay protection system shall be capable of distinguishing faulty zones for indication purposes to allow for ease of fault identification and repair.

c) The Contractor shall supply and install cable fault indication relay as per drawing CEE-TBD-7.

9.4 Services

a) The Contractor shall obtain the services of a specialist company for the full design of fire protection and intruder security systems.

b) The fire protection and intruder security designs shall comply with the requirements of the PRASA specification titled: “Substation, Relay Room and High Site Physical and Electronic Security”, which forms part of the Schedule of Specifications - Schedule B.

c) The fire protection system design shall comply with the Occupational Health and Safety Act, Act 85 of 1993, SANS 10400 and SANS 10139 latest amendments.

d) The security system design shall comply with the various applicable parts of SANS 10222 standards for Electrical Security Systems and Installations.

e) Training of personnel is of importance as the effectiveness of the system depends on the training and suitability of the personnel.

9.4.1 Fire Protection System

a) The fire protection specialist shall first conduct a fire risk assessment and provide a report with recommendations for PRASA’s acceptance.

b) The specialist shall design, supply and install a fire detection and protection system suitable for use on electrical machinery.

c) The fire suppression system shall be installed for fire protection inside the substation control building.

d) The inert gas fire protection system, using nitrogen gas cylinders, is the preferred method.

e) The fire detectors shall comply with SANS 50054-5 (heat) and SANS 50054-7 (smoke).

f) The alarms of the system shall be connected to the telecontrol system for remote monitoring from the fire protection control panel.

g) The design must comply with the Occupational Health and Safety Act, Act 85 of 1993 and the relevant SANS specification (i.e. SANS 10400, SANS10139).

h) The design of the fire protection system shall be interlocked with the ventilation fans, air vents, the 11kV AC incoming circuit breakers and 3kV DC HSCBs to shut down the substation when fire is detected.

i) It is the Contractor’s responsibility to ensure that such equipment is installed in the substation before any equipment is energised.

9.4.2 Intruder Security System

a) The security specialist shall conduct a risk assessment and provide a report with recommendations for PRASA’s acceptance.

b) The entire security system shall be connected to the telemetry system for remote monitoring from the security system control panel.

c) The security system shall include access control at the substation which is compatible with the existing dominant group system standard.

d) The access control shall include biometrics and vehicle license plate recognition.

e) The security system shall include an electric fence covering the entire fence height as well as an 8-strand electric fence above the entire perimeter fence.

f) The proposed electric fencing system shall include the following:

1) Fence energiser
2) Siren
3) Lightning diverters
4) High tension insulated electric cabling and conduit
5) Fence High voltage warning signs
6) Fence energised indicators
7) High tension galvanised steel wire forming part of the fence
8) Fencing posts, stays, intermediates, brackets, wire tensioners and insulators

g) The security camera system shall include intruder detection and alarm activation. The Perimeter Intruder Detection System (PIDS) shall detect the breach attempt and provide the location of the attempted breach in all weather conditions.

h) The security system shall include a CCTV system that will be linked to the off-site monitoring system via a network switch and optic fibre patch panel. Additional illumination for dark areas to enhance the camera vision during the night shall be included where necessary and the design shall comply with SANS 10389-2.

i) The following shall be considered when determining the placement of cameras:

1) All access points to the building including emergency escape doors.
2) Sensitive areas within the yard and around the building.
3) Adequate CCTV camera surveillance for the entire substation area.

j) All camera housing and mounting equipment shall be suitable to withstand the prevailing South African Railway environment conditions including but not limited to the following:

1) Interferences from 3kV DC traction system
2) Electrical stray currents
3) Vibrations
4) High Winds
5) Heat
6) Dust Particles

7) Rain

8) Corrosion

9) Tampering and Vandalism

k) The electromagnetic compatibility in the 3kV DC railway environment on emission immunity of the telecommunication and fixed power installation and apparatus shall be considered in the design.

l) The CCTV cameras shall produce sharp, detailed and stable images on the monitor in sufficient detail to provide positive identification of individuals within the protected areas under all conditions of light.

m) Type 1 and type 4 Internet Protocol (IP) based cameras shall be used for indoor and outdoor respectively as indicated in the PRASA security specifications.

n) A combination of fixed and pan, tilt and zoom configuration shall be used at every point or structure pole to maximise monitoring requirements.

o) All cameras shall be installed with a vandal and tamper proof mechanism.

p) The camera lenses for field view shall be capable of collecting light reflected from the scene and focusing it into an image onto the CCTV camera sensor by using the height of the image sensor (charge couple device – CCD).

q) Network Video Recording (NVR)

1) IP cameras shall be used with an NVR supporting infrastructure with Power over Ethernet (PoE) at the site of the camera using Cat 6 cables.

2) Recorded images shall have the time, date and camera location superimposed on the CCTV vision.

3) A Network Time Protocol (NTP) shall be used for clock synchronisation.

4) Watermarking on the CCTV vision shall be the feature of the system.

5) The CCTV systems shall achieve a frame rate of 25 (fps) or greater, regardless of the number of cameras connected.

r) Recording Capacity

1) Recordings shall be kept for a minimum of 30 days or more with capabilities to upgrade as and when required.

2) Movement detection feature shall be applied for all the recorded data to optimise the recorded capacity.

3) Access to the recorders shall be logged on a system management database integrated with the administration logging rights and history of activities and events.

4) Colour cameras shall be used inside the building.

5) Outdoor cameras shall facilitate the function to automatically switch to monochrome once the light intensity starts to drop.

6) The monitoring of the CCTV camera system shall be done at a remote security control site. Existing optic fibre transmission shall be used for connection between the substation and control office.

s) The Contractor shall supply and install intrusion detection door limit switches on all external doors, which shall be wired to the telecontrol.

t) The Contractor shall submit the designs to PRASA for approval before installation commences.

u) It is the Contractor's responsibility to ensure that such equipment is installed in the substation before any equipment is energised.

9.5 Take-Out Substation Work

a) The OHTE between Reunion and Umgeni stations will be refurbished by an OHTE Contractor as part of another PRASA project.

b) The SoW for the substation refurbishment project includes liaison with the OHTE Contractor.

c) Should the OHTE Contractor not be on site by the time that the substation Contractor executes Phase 2 of the substation refurbishment project, the substation Contractor shall supply and erect the OHTE feed-in structures next to the tracks as shown on the OHTE design drawings.

d) This will include the aerial busbars on the feed-in structures, jumpers onto the OHTE and the section insulators.

e) The Contractor shall also supply and install the aerial feeders between the substation feeder switch structure no.1 and the OHTE feed-in structures.

f) The feed-in structures can only be constructed during track occupations and under permit conditions. The Contractor shall arrange with PRASA for "Permits and Occupations" on the 3kV DC Electrification by applying to the Depot at least 6 weeks' in advance.

g) Track occupations and associated electrical permits can be granted between 22:00 and 02:00 as well as one eight (8) hour permit per month on a Sunday during daytime hours.

h) Tenderers shall therefore price for these items as a Take-Out on the BoQ.

i) If the OHTE Contractor is on site by the time material orders must be placed for the above material, the OHTE Contractor will supply and erect the feed-in structures as well as the aerial feeders.

j) This will be subject to PRASA's decision at the time of construction on whether to take out or include the above as part of the substation refurbishment project.

9.6 Defects and Liability

a) The contractor shall guarantee the satisfactory operation of the complete electrical installation supplied and installed by him and accept liability for maker's defects, which may appear in design, materials and workmanship.

1) The guarantee period shall commence from the date of successful commissioning of the substation.

b) The guarantee period for the substation shall expire after a period of 12 months commencing from the date of successful completion of the contract or the date the equipment is handed over to PRASA whichever is the later.

c) The Contractor shall make arrangements with the suppliers to ensure the provision of a 2-year warranty, that shall commence immediately after the 1-year guarantee period.

d) The Contractor's liability for any latent defects shall continue beyond the date of the Final Approval Certificate but the Employer shall have no claim against the Contractor arising out of any latent defect which first manifests itself later than the period of 5 years after the issue of the Final Approval Certificate in terms of this Clause.

10 CONSTRUCTION OF THE SUBSTATION

a) The Contractor shall submit a programme to the Employer, for acceptance. The programme shall indicate the following activities and durations as a minimum:

1) Contractor's design activities

2) Design approval periods.

3) Material and equipment orders as well as manufacture delivery periods, especially long lead items.

4) Proposed factory acceptance tests of major equipment.

5) Planned start date for construction activities on site.

b) The programme shall be submitted within 3 weeks after the contract kick-off meeting.

c) The Employer will ensure that the site is available and prepared in time for the Contractor to start with his activities.

10.1 Liaison with other Contractors and Stakeholders

a) The Contractor shall be responsible to liaise with eThekwini municipality and their appointed Contractor on site for the installation of the new MV supply cables to the 11kV incoming switchgear inside the substation building.

1) This will be required during construction, testing, commissioning and energising of equipment.

b) The PRASA substation Contractor is responsible for the termination and connection of the MV cable to the incoming switchgear.

c) The Contractor shall be responsible to liaise with the Contractor, appointed by PRASA, that will do the refurbishment of the OHTE between Reunion and Umgeni stations. See clause 9.5 , Take-Out Substation Work.

1) The liaison is regarding the placement of the OHTE aerial feeder structures next to the tracks on the north western side of the substation.

d) The Contractor shall liaise with Transnet regarding disconnecting the existing 33kV supply to Booth substation from Bayhead intake substation as part of the existing ring feed.

e) The Contractor shall also be responsible to liaise with Transnet Freight Rail regarding the two traction supplies to the TFR Goods Avoiding Line.

f) Tongaat Huletts Sugar for access to site. See clause 10.3 h) below

10.2 Decommissioning and Demolition

a) Decommission and dismantle the existing equipment and demolish the existing substation building. See clause 4 above for Stage Working.

b) Transport all other non re-usable decommissioned equipment to a scrap material lay down area that will be identified by PRASA and be within 30 km of the site. Tenderers shall however also quote for the transport of the scrap steel based on a km rate. This rate will be used should the identified site be beyond the 30 km limit.

c) All demolished material shall be neatly and safely stockpiled to occupy the least space.

d) Building rubble and waste shall be transported and dumped in an environmentally approved dumping site for rubble and waste.

e) Toxins such as Polychlorinated Biphenyls (PCB) that may be found in the oil of transformers or wave filter capacitors shall be handled and disposed of in compliance with the environmental regulations.

f) The equipment that the PCB contaminated oil was found in, shall also be disposed of in an environmentally friendly manner, as above, and not be transported to the depot.

g) Any asbestos that may be found in old equipment shall be handled by an authorised Contractor to do so and disposed of in an environmentally approved manner. Records of such products shall be kept as well as where it was disposed of.

h) Clear and prepare site for construction.

i) The Contractor shall compile an environmental plan for the identification, removal and disposal of PCBs and asbestos products in the equipment described above.

1) The plan must be submitted to PRASA for acceptance.

2) The Contractor shall ensure compliance with the accepted plan as part of the Quality Control process.

j) The Contractor shall conduct studies associated with spilled oil in the substation and ensure compliance with environmental standards.

10.3 Site Preparation

a) Setting out of the site levels for the earthworks and the preparation of the site shall be done by the Contractor.

b) The exact locations of underground services, electric cables, water mains, sewer and stormwater pipes and drains, etc are not known. The Contractor shall make provision for locating these services during site preparation and construction and record them to determine whether or not they are still in use.

c) The existing ClearVu perimeter security fence shall remain. The fence shall be lifted in areas where the substation platform must be raised for stormwater drainage. See clause 11.1.8 d) below.

d) The Contractor shall supply and install the kerbing and ramp at the access gates in accordance with the substation security fence layout drawings listed in Schedule A.

e) The access ramp and new internal fencing shall not be installed prior to the installation of the transformer and major associated equipment that could damage the fences during delivery and construction.

f) Should the existing security fence be damaged during construction, the Contractor shall repair the fence to the required security level.

g) The Employer will authorise the timing of the installation of the access ramp and internal fencing and kerbing.

h) Access to the site shall be by means of the existing access road, from South Coast Road through the marshalling yard of Tongaat Huletts Sugar.

10.4 Earth Works for the Substation Platform

a) The substation shall be built on the platform to be constructed as shown on the drawings listed in Schedule A.

b) The earth works and the platform shall be constructed by the Contractor.

c) The substation platform will be inspected and signed off by the Employer and the Contractor prior to any construction of foundations, the substation building or support steelwork on the prepared platform.

10.5 Ground Conditions

a) A geotechnical report on the ground conditions of the site forms part of the Works Information as an attachment.

b) Should the Contractor require additional information, which is not covered by the above-mentioned geotechnical report, he shall make his own arrangements to obtain such information and allow for it in his price.

c) The Contractor shall further allow for any tests necessary to ascertain ground-bearing pressures as part of the supporting information on foundation casting locations.

d) Test results shall be submitted to the Employer at the various holding points as indicated on the quality control plan to be provided by the Contractor.

10.6 Foundations

10.6.1 General

a) The detail equipment and foundation layout drawings showing the positions of all equipment as well as the substation building in the traction substation yard are part of the listed drawings in Schedule A.

b) The detailed building foundation design forms part of the Employer's designs listed in Schedule A.

c) The Contractor shall be responsible for the excavation and casting of all foundations for the substation equipment structures, lighting and lightning poles as well as the control building within the substation yard.

d) The general design and layout of all equipment makes provision for easy and safe access to and around equipment for construction and maintenance purposes.

e) The clearances between equipment may not be altered without prior acceptance from the Employer.

f) The equipment, especially the traction transformer, shall be installed in such a manner as to limit fire damage, which may be caused by equipment failure, overheating or flashovers.

g) The top of all equipment support foundations shall be finished-off, minimum 200mm above the finished platform level in the yard.

h) All foundation edges shall be bevelled at 45° and the surfaces shall be steel float finished.

i) The construction shall be such as to prevent standing water on top of the foundations.

j) The top of all multiple support foundations for the same equipment shall be at the same level.

k) A double walled flexible HDPE sleeve pipe, with smooth inner wall and corrugated outer wall, shall be cast into all concrete foundations for earth and control cabling to be taken up the structure. The structure hold-down bolt groups shall be bonded together with earth straps and bonded to the substation earth mat on two opposite sides of the foundation.

l) The Contractor shall determine beforehand on which side of the equipment the control/power cabling is situated to ensure that the sleeve pipes are installed in the correct position in the foundations.

m) The foundations for the two feeder switch structures shall be as per the TFR drawings listed in Schedule A.

10.6.2 Concrete for Foundations

a) The 28-day strength of all concrete to be used shall be a minimum of 20MPa unless otherwise specified and shall comply with Specification S420.

b) If ready-mix concrete is used, it shall be supplied with test certificates to confirm the concrete strength.

c) The Contractor shall be responsible to arrange for sampling and testing of all concrete used and shall furnish test cube results to the Employer.

d) Hand mixed concrete is not acceptable.

e) Only mechanically mixed concrete will be accepted.

f) The addition of water to a concrete mix reduces the strength of the concrete very significantly and on no account, may water be added to a mix after test cubes have been taken.

g) There shall be a minimum of 50mm concrete cover around all steel reinforcing of structural bearing foundations.

h) All concrete shall be vibrated throughout the pouring process to ensure a solid foundation with a smooth finish.

10.6.3 Concrete Plinths and Bund Walls for Transformers

a) The design of the concrete plinths for the transformers include a concrete gutter or bund around the perimeter of the plinth to contain any spillage of transformer oils. The design is shown on the drawings listed in Schedule A.

b) Oil sump pits shall be provided with oil separation arrangement for each bund.

c) The design includes details of an oil trap clearly showing how rainwater will be released from the confined area without the oil being released at the same time.

d) A 110mm diameter double walled flexible HDPE sleeve pipe, with smooth inner wall and corrugated outer wall, shall be cast into the transformer plinth for the routing of the control and protection cables.

e) 160mm diameter double walled flexible HDPE sleeve pipes shall be cast into the transformer plinth for the routing of the 11kV supply cables from the primary circuit breaker to the transformers.

f) Sleeve pipes shall also be installed in the plinth for the routing of the LV cables from the auxiliary transformers into the building for the supplies to the AC/DC distribution panel.

g) The ends of these pipes in the plinths shall be positioned such that the cables enter the transformer connection points vertically.

h) The two insulated earth conductors connecting the traction transformer tanks to the primary of the AC earth leakage CT, at two places, shall be installed in separate dedicated HDPE sleeve pipes.

10.7 Steel Support structures

a) The Contractor shall supply and install all steel structures for the support of equipment and tensioning of conductors as per the designs shown on the drawings listed in Schedule A.

b) Special attention shall be taken for the prevention of corrosion of all metallic parts.

c) The bases of studs, bolts, support structures and other parts made of ferrous material associated with the electrical connections outdoors, shall be hot-dipped galvanised, in accordance with SANS 121.

d) Steelwork for outdoor installation in coastal areas, shall be hot-dipped galvanised to SANS 121 and painted tower grey in accordance with CEE.0045.

e) Structural steel shall comply with SANS 1431. All welded joints shall be seal welded with no gaps or blowholes.

f) All fasteners, nuts and bolts used for the installation of substation steelwork and equipment shall be hot-dipped galvanized to prevent corrosion.

g) Electroplated material will not be accepted.

h) All steel sections, brackets and beams, which need to be bolted, shall be secured with fasteners using flat and lock washers. Bevelled washers shall be used on steel sections having tapered flanges.

i) Mast base insulation shall be installed between the foundations and steel masts of the feeder switch structures as shown on the drawings listed in Schedule A.

10.8 Substation Control Building

a) The Contractor shall supply material and construct a substation control building as shown on the architectural, civil and structural drawings listed in Schedule A.

b) The building shall accommodate all the substation indoor equipment listed below as a minimum.

1) 11kV MV switchgear.
2) Rectifiers.
3) Reactor coils.
4) Wave filter equipment.
5) Positive isolators.
6) High speed circuit breakers.
7) 3kV DC busbar earth switches.
8) AC / DC Distribution panel.
9) Primary circuit breaker control panels.
10) Battery charger and battery bank.
11) Telecontrol panel.
12) DC Earth leakage busbar and relay.

c) The battery room in the building shall have a steel sink for washing of hands and battery instruments.

d) The water supply to the sink, toilet and wash hand basin shall be from a municipal water main near the substation. The Contractor shall determine the exact position thereof or, if not available, arrange with the municipality to provide such a water point.

e) The wastewater from the sink, toilet, and wash hand basin shall be connected to the municipal wastewater system near the substation. The Contractor shall

determine the exact position thereof or, if not available, arrange with the municipality to provide such a connection point.

1) Alternatively, if a sewer connection point cannot be supplied at the substation, the Contractor shall design, supply and install a sewer pump system for discharging into the nearest available point.

f) The items listed below shall be installed within the building as part of the building.

1) Suitable brackets and/or storage for a ladder, special tools and portable earthing apparatus.

2) A wooden self-supporting ladder of robust construction with a height not exceeding 1.2m.

3) A wall mounted key box with a lid / door and provision for at least 20 keys.

4) Suitable wall brackets for mounting of fire extinguishers.

5) Appropriate fire extinguishers shall be provided by the Contractor.

6) A steel cabinet / desk combination approximately 1150mm wide, 600mm deep and 1200mm high.

7) A complete set of wiring and circuit diagrams in a durable folder to be stored in the cabinet / desk.

8) A substation layout and switching diagram contained in a suitable A1 size picture frame/s covered with a translucent material. The frame shall be attached to the wall above the desk.

9) Wall mounted low voltage distribution board

11 INSTALLATION

a) This document must be read in conjunction with specification BBB 5452 “TFR’s Requirements for the Installation of Electrical Equipment for 3kV DC Traction Substations” as well as any other related specifications and drawings.

b) This part refers to certain portions of specification BBB 5452 and highlights any requirements that may be different but applicable to this project.

c) This part also specifies any deviations and additions from which might be specified in other TFR generic specifications forming part of this document.

d) The installation of the equipment required for the construction of the substation will be carried out in accordance with the final designs done by the Consultant’s and Contractor’s Professional Engineers and accepted by the Employer.

11.1 Outdoor Equipment

This section covers the requirements of outdoor equipment, cable connections between outdoor equipment and indoor equipment as well as municipal incoming supply cables and feeder cables to the OHTE.

11.1.1 Traction Transformers

a) The transformers shall be installed on separate concrete plinths inside the bund areas in the HV yard.

b) The transformer tanks shall be electrically insulated from their plinths to at least 10Ω. The tanks shall be bonded to the AC earth leakage busbars with two insulated earth cables from two opposite connection points on the tanks.

c) In addition to factory testing, the transformers shall again be tested upon delivery to site to ensure its integrity.

d) The Contractor shall supply and install busbars with removable flexible connections from the traction transformers' secondaries to the anode wall plate bushings.

11.1.2 Auxiliary Transformers

a) The transformers shall each be installed on the concrete plinths inside the bund areas next to its respective traction transformer.

b) The primary sides of the auxiliary transformers shall be connected to the 2.36kV tertiary winding of each traction transformer.

c) The secondary sides shall be connected to two separate LV cables to supply power (two separate supplies) to the AC / DC distribution panel.

d) The LV supply cables from the transformer secondary windings shall be protected by two separate LV withdrawable circuit breakers.

e) The withdrawable circuit breakers shall each be installed in a weatherproof (IP55) stainless steel powder coated enclosure on the plinths next to the transformers.

11.1.3 Substation Yard Lighting

a) LED type luminaires shall be supplied and installed on the outside of the substation building as shown on the building lighting layout and LV reticulation drawing.

   1) The luminaires for illumination around the building shall be of the wall mounted bulkhead type.

b) The Contractor shall supply and install 230V AC LED type luminaries in the substation yard to provide a general level of illumination of not less than 20 lux.

c) The luminaires shall be mounted at 6m above ground level on steel lighting and lightning poles.

d) The positions of the lighting poles and the orientation of the luminaires are shown on the outdoor yard equipment layout drawing.

e) All the outdoor yard lights shall be operated by light sensitive day / night control units.

f) Care shall be taken to avoid glare from yard lights in the eyes of train drivers.

11.1.3.1 Light Sensitive Day / Night Control Units

a) Two units shall be used and be placed where it will be least affected by the substation outdoor lights as well as lighting from neighbouring properties. The units shall be mounted against the building wall in a position giving coverage of the northwest hemisphere.

b) Each complete unit shall be of the solid-state electronic type and housed in a sealed weatherproof casing, suitable for mounting in any position.

c) The light sensitive control unit shall have an impact resistant translucent cover to protect the light sensor from physical damage.

d) The cover shall be suitably protected against the effects of ultra-violet radiation.

e) The unit shall be supplied complete with a suitable mounting bracket or be provided with a single hole fixing for 20mm conduit thread including lock nuts and gaskets.

f) The unit shall not operate for light fluctuations shorter than 5 minutes' duration.

g) The unit shall incorporate a relay for switching the lighting circuits having main contacts rated at not less than 16 Amps.

11.1.4 Buried XPLE Cable Feeds

11.1.4.1 11kV AC MV Cables

a) The Contractor shall supply and install suitably rated buried 11kV AC XLPE type A copper cables between the indoor primary circuit breakers and the traction transformers. The Contractor shall determine the size and number of cables to be used.

b) The installation shall be complete with terminations and connections to the equipment.

11.1.4.2 3kV DC Positive Feeding Cables

a) The new feeding cables from the HSCBs to the feeder switches shall be supplied and installed in accordance with clause 37.1 of BBB 5452 with at least 2x500mm^2 single core type A 6.6kV XLPE copper cables per positive circuit.

b) This include cables to the two new switch structures inside the substation yard as well as to two existing feeder switches on the TFR Goods Avoiding Line. These two switches will remain and the Contractor shall only replace, terminate and connect the cables to the switches.

c) Notwithstanding clause 37.1.7 of BBB 5452, the Contractor shall be responsible for all the Works necessary for cables to pass under the tracks, where required.

d) The Contractor shall supply and install 110mm diameter HDPE sleeve pipes for all the positive feeder and negative return cables where they cross the railway lines. The depth of the sleeve pipes shall be at least 1m deep.

e) The Contractor shall further supply and install 110mm diameter HDPE sleeve pipes for all the positive feeder cables crossing the substation yard to the switch structures, at a depth of 1m.

f) The Contractor shall supply and install a new negative return system using suitably rated buried XLPE single core cables with at least 4x500mm^2 single core type A 6.6kV XLPE copper cables between the negative return manhole and the substation negative return busbar.

g) The Contractor shall supply and install a new negative return manhole with a busbar for connection of the abovementioned cables and new bonds from the track.

1) The new manhole shall be in accordance with drawings BBG 1704 and BBG 1705.

2) The new negative return bonds shall be supplied and installed in accordance with specification BBC1678 and BBB5608.

h) The Contractor shall design, supply and install a negative feeder monitoring system in accordance with specification BBC 1844.

11.1.5 Cabling, Busbars and Wiring

a) All cabling and wiring shall be installed, terminated and connected in accordance with SANS10142-1, specifications BBC 0198, CEE 0023 and clause 34 of BBB 5452.

b) The cables shall be supplied in accordance with specification BBC 0198.

c) The Contractor shall supply and install all cabling and wiring for connection between the equipment supplied.

d) The Contractor shall determine all cable, wiring and busbar sizes based on their total lengths, the current they will carry for the equipment supplied and environmental conditions under which that they will operate.

e) All cable routes shall be indicated on the Contractor's cable layout to be approved by the Employer.

f) No deviations will be allowed without the approval of the Employer.

g) Joints in cables, flexible wired busbars and conductors shall not be permitted. All cables, wired busbars and conductors used shall be long enough for the intended purpose.

h) All armoured cables shall terminate in mechanical type glands.

i) These glands shall be secured in correctly sized holes in gland plates and fitted with neoprene shrouds.

j) Block jointing of all armoured cables shall be done in accordance with clause 33.24 of specification BBB 5452, this shall include all cables entering the substation building from the substation yard.

k) All low voltage cables shall be terminated and connected to terminal strips inside the panels and equipment.

l) All connections shall be tight.

m) The cable routes for the medium voltage cables shall be marked by cable markers painted brilliant green (H10), while cable markers for low voltage cables shall be painted black (S).

n) Cable markers shall be in accordance with drawing no. CEE-PK-14 but having the PRASA name.

o) All cable routes shall be provided with a continuous cable warning tape laid directly above each cable and installed 150mm below platform level for the full length of the cable.

p) The backfilling of trenches shall be done in accordance with specification CEE 0023.

11.1.6 Earthing, Bonding and Outdoor Lightning Protection

a) The Contractor shall design supply and install a substation outdoor earth termination system (earth mat) in accordance with clause 30.0 of specification BBB 5452, specification BBB 3059 and drawing no. BBB 3620 in as far as applicable.

   1) An earth resistivity measurement shall be taken in the substation yard and a report submitted on the outcomes of the measurements.

   2) The design of the earth mat shall be based on the earth resistivity measurement using the appropriate software tool.

   3) The earth mat design shall also comply with specifications IEEE 80 requirements.

b) The earth mat design shall comply with the following minimum requirements:

   1) The maximum step and touch voltages shall be within safe tolerable limits.

2) The grid potential rise shall not exceed 5000V during a discharge.

c) Sacrificial anodes shall be supplied and installed in the substation yard. The anodes shall be bonded to the earth mat.

d) All fence posts and gates shall be bonded to the earth mat.

e) Flexible bonds shall be provided between the swing gate frames and their posts. These bonds shall be fitted with lugs on both ends and bolted to the gate frame and fence posts.

f) A 14m high combination lighting and lightning mast shall also be supplied and installed as shown on the outdoor yard equipment layout drawing.

g) The lightning mast shall be connected to the earth mat.

11.1.7 Crusher Stones

a) The Contractor shall remove all vegetation, apply an approved weed killer that is environmentally suitable for local conditions and lay a new layer of crusher stones in the entire outdoor yard, as shown on the layout drawings.

b) Notwithstanding clause 43.3 of BBB 5452, the crusher stone shall be a 100mm thick layer of 19mm stone having a wet resistivity of 3000Ω.m.

11.1.8 Fencing, Kerbing, Gates and Access Ramp

a) The extent of all fences and gates including kerbing are shown on the layout drawings listed in Schedule A.

b) Notwithstanding clauses 41 and 42 of specification BBB 5452, the following requirements shall apply to this project: -

1) The Contractor shall supply and install 1.8m high internal diamond mesh fences and pedestrian gates at the traction transformers.

2) Gate switches shall be supplied and installed on each pedestrian gate. Each switch shall be in the closed position when that particular gate is open connecting the substation earth mat to the negative return. The switch shall be in the open position when the gate is closed disconnecting the substation earth mat from the negative return.

3) A gas arrester spark gap shall be supplied, installed and connected between the two terminals of each gate switch. Refer to drawings BBB 0906, CEE-TBD-7 and BBB 3620 as well as specification BBB 1616 and all referenced documents.

4) A vehicle access concrete ramp shall be constructed at the substation access gate as per the civil and structural drawings listed in Schedule A.

c) The fences, kerbing and access ramp shall only be installed or constructed once all major items of equipment and steelwork have been delivered and installed.

d) In areas where the existing ClearVu perimeter fence must be lifted to maintain the fence height due to raising the substation platform as part of the earth works, the Contractor shall remove the fence and reinstall it by casting the fence posts in 300 x 300 x 500mm deep concrete foundations. The concrete strength shall be 25MPa.

1) A 200 X 300mm deep anti-digging concrete beam shall be cast along the portions of the fence that was lifted. The concrete strength shall also be 25MPa.

11.1.9 Traction Substation Building

a) The Contractor shall supply and construct/build a suitable substation control building as per the Civil and Architectural drawings listed in Schedule A.

b) The building shall accommodate all medium voltage, low voltage, monitoring, protection and control equipment and all associated relevant DC equipment including furniture.

c) The construction of the building, the building services and equipment used shall conform to SANS 10400.

11.2 Indoor Equipment

a) This section covers the requirements for the installation of indoor equipment, cabling, wiring and earthing.

b) The equipment layout is shown on the building equipment layout drawing listed in schedule A.

11.2.1 11kV AC MV Indoor Metal Clad Switchgear

a) The MV indoor switchgear shall be installed as shown on the substation building equipment layout drawing listed in Schedule A.

b) The arrangements in the circuit shall be as indicated on the single line and protection diagram of the Employer's design shown on the drawings listed in Schedule A.

11.2.2 Anode Wall Plates and Bushings

a) The Contractor shall supply and install anode wall plates complete with bushings. The bushings shall be adequately rated for the output of the 10MVA traction transformers.

b) The wall plates and bushings shall be as shown on the anode wall plate drawing listed in Schedule A.

11.2.3 3kV DC Rectifiers

a) The 10MW rectifiers shall be installed in two separate screened-off Rectifier Bays inside the building.

b) The rectifiers shall be insulated from the building floor.

11.2.4 Reactor Coils

The reactor coils shall be installed in the fenced-off Rectifier Bays, one per rectifier unit.

11.2.5 Wave Filter Equipment

The wave filter equipment shall be installed in the two wave filter rooms, leading off the Rectifier Bays.

11.2.6 3kV DC Positive Isolators

a) The positive isolators shall be installed in the fenced-off Rectifier Bays.

b) The positive isolator enclosures shall be the same height as the Rectifier Bay fence with the fence on the two sides of them.

c) This will allow access to the operating handles.

d) The Contractor shall supply and install suitably sized copper conductors between the positive isolator and the 3kV DC busbar having a continuous current rating of 4000A.

11.2.7 3kV DC Under-Voltage Relays

The 3kV DC under voltage relays shall be accommodated inside the 3kV DC positive isolators.

11.2.8 3kV DC High Speed Circuit Breakers and Cells

a) The modular steel cells and circuit breakers shall be installed in a row next to each other as shown on the building equipment layout drawing.

b) The 3kV DC busbar earthing switches shall be installed on the ends of the row of circuit breaker cells as shown on the layout drawing.

11.2.9 Negative Return Monitoring System

The panel of the monitoring system shall be installed inside the substation building next to the substation negative return busbar.

11.2.10 Battery Charger and Batteries

a) The battery charger shall be installed inside the building as shown on the building equipment layout drawing.

b) The batteries shall be installed inside the battery room of the building.

11.2.11 Telecontrol Outstation Panel

a) The telecontrol panel shall be installed inside the building as shown on the layout drawing.

b) The Contractor shall be responsible to connect the necessary circuits required for telecontrol functions in the control and protection panels to a terminal strip inside the control panel.

c) Termination and connection of the multi-core control cables into the control panels and the telecontrol panel shall be done by the Contractor.

d) The Contractor shall label all the cables and cores at both ends of the specified multi core cables at the control and protection panels, the terminal strips and the telecontrol panel.

e) The Contractor shall test the functionality of the entire telecontrol system before the energizing of the substation equipment (the installation of the telecontrol equipment is included in another part of this contract).

f) The Contractor shall provide a commissioning certificate for the telecontrol installation.

g) The Employer shall endorse this certificate to indicate acceptance with the telecontrol installation.

h) The Contractor shall be responsible for the preparation of such a certificate and he shall include it as part of the overall substation commissioning report.

11.2.12 Primary Circuit Breaker Control and Protection Panels

The panels shall be installed as shown on the building equipment layout drawing.

11.2.13 AC/DC Distribution Panel and Change-over Panel

a) The distribution panel shall be installed as shown on the building equipment layout drawing.

b) The two LV supply cables from the two auxiliary transformers shall be connected to the automatic changeover inside the AC/DC panel.

11.2.14 Supply and Installation of Cables as per BBC 0198 and CEE.0023

a) The Contractor shall prepare a cable layout and schedule covering all cables in the entire substation complex, as required. The cable layout shall show the planned routes of all cables between different pieces of equipment. The cable schedule shall indicate cable and core numbers of all cables.

b) A cable management design for the accommodation of all cables in the entire substation complex shall also be prepared by the Contractor. The design shall show where and how cables will be laid in the ground and supported in sleeve pipes, trunkings and cable trays.

c) The design shall be submitted to the Employer for approval.

d) No deviations from the approved layout will be permitted without approval from the Employer.

e) Cables in the outdoor yard shall run in trenches directly in the ground and in masonry trenches inside the building.

f) All trenches inside the building shall be covered with chequered plates.

g) The top of the chequered plates shall be at the same level as the rest of the building floor.

h) The Contractor shall cut all slots in chequer plates for emerging cables.

i) The edges of the slots shall be filed smooth to avoid damage to cables.

j) Where trenches inside the building are not suitably close to equipment, portions of cables outside trenches shall be routed in PVC conduit or PVC surface mounted channels, having removable covers.

k) These conduits or channels shall be wall mounted and be of sufficient size to easily house the conductors.

l) These channels or any other wireways shall not be laid on floors over access ways.

m) All cables shall be terminated and connected to a terminal strip/s inside the panels.

n) Insulated lugs, of the crimp on type, shall be used to terminate wiring on to equipment and strip connectors.

o) All crimping lugs shall be hexagonally compressed with a crimping tool.

p) All wiring for DC circuits shall be done in grey coloured wire.

q) Cables and conductors and/or supports that are attached by adhesives are not acceptable.

r) Joints in cables and aerial busbars will not be permitted.

s) The Contractor shall only install cables that are long enough for each application.

t) All wiring and cabling shall be carried out in accordance with SANS 10142, specification CEE.0023 and clause 33 of installation specification BBB 5452.

u) All busbars used to interconnect equipment on the 3kV DC circuit shall be rated at 3000A with the main 3kV DC busbar rated for 6000A.

v) The Contractor shall also be required to supply and install all cabling required to the telecontrol panel in accordance with clause 13.0 of specification BBB 2721.

w) The contractor shall supply and install buried XLPE single core type A, 500mm² copper cables, at least two in parallel per positive feeder circuit.

x) The contractor shall supply and install buried XLPE single core type A, 500mm² copper cables at least four in parallel for the substation negative return circuit.

y) Cable sleeve pipes in external walls of the building shall be sealed after the installation of all cables. Sealing shall be done utilising filler material between cables and the rest of the pipe sealed with liquid or foam sealant. The sealant shall be fireproof, watertight, UV resistant and vermin proof and prevent the ingress of any moisture into the building.

11.2.15 LV Distribution in the Substation Building

11.2.15.1 General

a) The Electrical Contractor shall carry out the installation in accordance with SANS 10142-1 and the requirements as laid down in this specification.

b) The Contractor shall furnish a certificate of compliance for the entire low voltage distribution system signed by an accredited person in terms of SANS 10142-1 on completion of the installation. This person shall be registered with the Electrical Contracting Board.

11.2.15.2 Distribution Board

a) A low voltage distribution board shall be installed against the inside wall of the substation building to supply power to the building services (lights, SSO).

b) The distribution board shall be provided with a main circuit breaker or isolator and MCB'S to protect all outgoing circuits (lighting and switched socket outlet circuits). MCB's shall comply with SANS 156.

c) Provision shall be made for 20% spare MCB’s for future additions.

d) In addition to the spare MCB’s the distribution board shall have space for 30% additional space for future circuit breakers and circuits to be added.

11.2.15.3 General Purpose Wiring

a) All wiring shall be installed in wire ways and/or conduit as specified.

b) Open wiring is not acceptable.

c) Only the loop-in system of wiring shall be acceptable.

d) Joints in the wiring shall not be permitted.

e) All wires shall be stranded copper conductors. No surfix or twin and earth wiring will be accepted.

f) Wiring for AC and DC circuits and of different voltages shall be installed in separate conduits.

11.2.15.4 Miniature Circuit Breakers

All MCB's for protection of DC circuits shall be double pole and suitably rated for DC applications.

11.2.15.5 Galvanised Steel Tubing and Associated Fittings

a) Provision shall be made for the use of steel galvanised conduits to accommodate all light circuits between the distribution board, light fittings and switched socket outlets.

b) Where conduit is exposed to the weather elements only galvanised conduit shall be used.

c) Threads of metallic conduit and associated fittings exposed to moisture or the weather elements shall be effectively protected against rust with anti-corrosive paint.

d) Light fittings or other equipment shall not be used as wire ways.

11.2.15.6 Light Switches and Switch Socket Outlets

a) The Contractor shall supply and install light switches and switched socket outlets (SSO) at positions indicated on the building equipment layout drawing listed in Schedule A.

b) The SSO shall comply with SANS 164-2.

c) All surface mounted wall boxes shall be manufactured from sheet material of at least 0.8mm thickness and powder coated.

d) Wall boxes for SSO shall be 100 x 100 x 35mm with 20mm knockouts on the top, bottom and sides.

e) Wall boxes for light switches and isolators shall be 100 x 50 x 35mm with 20mm knockouts on the top, bottom and sides.

f) Wall outlet boxes for light switches shall be mounted 1350 mm from floor level and where possible 200 mm from door openings.

g) No Light switches and switched socket outlets shall be installed in the battery room.

h) All exterior light switches or switched socket outlets, where required, shall be installed in a weatherproof enclosure.

11.2.15.7 Light Fittings

a) The Contractor shall supply and install lighting in all internal areas to provide a minimum maintained average illumination level of 200 lux.

b) Light fittings shall be of the industrial LED type suitable for the environment in which they need to function.

c) Industrial type emergency LED light fittings shall be supplied and installed in the building as shown on the layout drawing. The power supply will be from the DB to the light fittings at 230V. Each emergency fitting shall have its own battery backup and converter system.

d) Light fittings installed in the battery room shall be rated for the zoned location.

11.2.16 Cooling and Ventilation

a) Further to clause 46.0 of specification BBB 5452, the Contractor shall design, supply and install suitably rated fresh air supply and extractor fans complete with the required weather louvers, fan guards and filters, as specified.

b) Two separate supply air ventilation fans shall be installed to supply fresh air at a minimum rate of 1200 l/s per fan.

c) Three separate extract air ventilation fans shall be installed to extract warm air at a minimum rate of 700 l/s per fan.

d) Each ventilation fan shall have its own independent local isolator to isolate the supply for maintenance purposes.

e) The on/off operations of the ventilation fans shall be controlled from two thermostat control switches via contactors in the AC/DC distribution panel.

   1) The thermostat control switches shall be situated near the rectifier units. Their exact positions will be determined on site.

   2) The control switches shall be wired in the control circuits of the contactors.

   3) Should any one of the two control switches close due to a rise in the internal building temperature, all the ventilation fans shall be switched on. The fans shall only switch off when the temperature has dropped below the set value and both switches are open.

f) Each fan unit shall have its own separate filter box with a removable filter drawn from the side for cleaning or replacement.

g) The ventilation system shall not be of the ducted type.

h) The battery room extractor fan, complete with a local isolator, shall be appropriate for the zone location and rated for 150 l/s. This fan shall operate continuously and not be controlled by the thermostat switches in the main room.

i) The supplies to all the fans shall be interlocked with the fire detection panel to shut all ventilation in case of detecting a fire in the building.

11.2.17 Indoor Earthing

The Contractor shall supply and install indoor earthing according to clause 29 of specification BBB 5452 and drawing no. CEE-TBD-7.

11.2.17.1 AC Earth Leakage Protection

a) The earthed conductive parts of the 11kV switchgear panels, equipment bases and frames in the 11kV switch room shall be insulated from the substation building structure (walls and floor) and be bonded to the AC earth leakage busbar. See clause 9.3.12

b) The switchgear panels shall be electrically insulated from the building floor to at least 10Ω.

c) A spark gap type gas filled arrester shall be supplied and installed in the 11kV switchgear room. The terminals of the spark gap shall be bonded to the AC earth (earth mat) and the negative return busbar.

d) A door type switch shall be supplied and installed on the inside of the external door of the 11kV switchgear room. The switch shall be in the closed position when the door is open, connecting the substation earth mat to the negative return. The switch shall be in the open position when the door is closed disconnecting the substation earth mat from the negative return.

11.2.17.2 DC Earth Leakage and Cable Fault Protection

a) The DC earth leakage busbar and relay shall be installed as shown on the building layout drawing.

b) The DC earth leakage relay protection system shall be capable of distinguishing faulty zones for indication purposes to allow for ease of fault identification and repair.

c) The earthed conductive parts of all panels and equipment bases and frames, excluding those in the 11kV switchgear room, inside the substation building shall be insulated from the substation building structure (walls and floor) and be bonded to the DC earth leakage busbar in accordance with clause 5.2 of specification BBB 3059 and clause 29 of specification BBB 5452.

d) The Contractor shall supply and install cable fault indication relay as per drawing CEE-TBD-7.

11.3 Mechanical Interlocking

An interlocking system shall be supplied and installed for isolating and earthing of the MV equipment and conductors in the traction substation. This is required as a safety measure to only allow access to equipment after live conductors have been isolated and earthed.

a) The interlocking system shall be of the trapped key exchange mechanical type.

b) Full details of the type offered shall be submitted for acceptance by the Employer.

c) The mechanical interlocking system shall be designed to prevent any access to live MV equipment and ensure that switching and isolating operations are carried out in the correct sequence.

d) All equipment shall be delivered with the necessary interlocking devices already fitted.

e) It shall not be possible to operate the locks and/or release the keys in any but the correct sequence or in any position of the switches or gates, other than the fully "closed" or fully "open" position.

f) When a particular traction unit is switched to local control, isolated and earthed, no remote switching from the electrical control office shall be possible.

g) The Contractor shall furnish full explanatory details of the arrangement whereby the foregoing provisions are met.

h) The track feeder breakers shall remain closed throughout this isolation procedure.

11.3.1 Isolating and Earthing Procedure

a) The following is the sequence to isolate and earth rectifier unit A of the double unit substation:

1) Trip the unit A 11kV MV AC primary circuit breaker.

2) Withdraw the circuit breaker and earth the load side cable. Key “1a” will be released from mechanical interlock position “1a”.

3) Remove key “1a” from lock position “1a”. The earth switch shall be locked in the close and earthed position.

4) Insert key "1a" into lock position “1a” on the lockable fuse isolator and earth switch in the AC/DC distribution panel. Open the isolator and close the earth switch. Key “1a” is now trapped in position “1a” and key “2a” will be released from the interlock position “2a”.

5) Remove key “2a” from lock position “2a”. The isolator will be locked in the open and earthed position.

6) Insert key "2a" into lock position “2a” on the 3kV DC positive isolating and earthing switch enabling this switch to open. Open the isolator and close the earth switch. Key “2a” is now trapped in position “2a” and key “3a” will be released from the interlock position “3a”.

7) Remove key "3a" from position “3a” on the 3kV DC positive isolating and earthing switch. This isolating and earthing switch is now locked in the open and earthed position.

8) Insert key "3a" into the lock on the Rectifier Bay gate and turn the key in order to open the gate. Key “3a” is now trapped in the bay gate lock.

9) If several equipment is required to be isolated before the Rectifier Bay gate may be opened and more than one interlocking key must be used, a multiple key exchange box shall be used.

10) The procedure must be done in reverse order to switch the substation back on load.

11) The same sequence shall be followed to isolate and earth rectifier unit B, except that keys and lock positions 1b, 2b, and 3b shall be used.

12) The foregoing sequence is given as a guide and may be altered to suit particular equipment offered. The design of the system shall be approved by the Employer.

13) Any deviation from the above guideline must be approved by Employer.

11.4 Warning Boards, Danger Signs and Phase Colour Boards

a) A substation name board shall be provided to clearly show the name of the substation.

b) The name board shall be manufactured in accordance with drawing no. 1656-002-SUB-E010.

c) Danger warning notices as per drawing no. CEE-TWN-0002, CEE-TWN-0010, CEE-TWN-0035, CEE-TWN-0037, WW23 and CEE-TWN-0006 shall be supplied and fitted to the substation building access doors, substation gates and to the perimeter fence.

d) On request from the Contractor, the Employer will indicate to the Contractor the exact positions of the sign boards.

e) All signs shall be supplied complete with supporting brackets, bolts and nuts.

f) Phase colour identification shall be applied to the Traction Transformers.

g) The rectifier unit shall be clearly labelled.

h) All nameplates and warning boards shall be in English.

i) All labels shall be made of a composite sandwich type plastic material of the following colour combinations:

1) Identification labels – White lettering on Black background. Letters must be of sufficient size to be clearly legible from a distance of 3m.

2) Danger labels – White lettering on Red background. Letters must be of sufficient size to be clearly legible from a distance of 3m.

j) All labels shall be neatly secured with rivets, screws or bolts and nuts.

k) All symbols and names on boards and danger signs shall be silk screened on to equal or similar approved to Chromadek plate with “Miracle Ink”.

l) All danger boards and signs shall comply with SANS 1186.

m) All labels shall be mounted in a steel galvanized frame attached with bolts to equipment, buildings and fences.

n) The labels shall not have sharp corners but rather smooth bevelled edges.

o) The following is a list of switchgear equipment labels that must be attached to the switchgear

1) On (I)

2) Off (O)

3) Open (Verb.)

4) Close (Verb.)

5) Closed

6) Open

7) Trip

8) Local

9) Remote

10) Open and earthed

The proposed labelling scheme must be submitted to the Employer for acceptance prior to the manufacture of the labels.

12 TESTING, PRE-COMMISSIONING AND COMMISSIONING

12.1 Payment Clause Definitions

a) “Commissioning” used in the clauses below shall imply pre-commissioning and / or commissioning but for payment purposes the following definitions shall apply: -

1) Pre-commissioning will generally imply: -

(i) Generally FAT and SAT.

(ii) Generally, all Works required up to pre-energising.

(iii) Practical Completion Certificate.

2) Commissioning will generally imply: -

(i) Training.

(ii) Hand-over (Operating and Maintenance Manuals and Data Packs).

12.2 Type and Routine Test Requirements

a) Type and routine tests shall be conducted on all equipment to be supplied.

b) These tests shall be carried out at the Contractors expense.

c) Test certificates in respect of type tests conducted on similar equipment or computer simulations will not be accepted.

d) Delivery of equipment shall not commence before acceptance of type and routine test certificates by the Employer.

e) The Contractor shall test all concrete used for the construction of the Works and the results shall be submitted to the Employer for acceptance.

12.3 Factory Acceptance Tests (FAT)

a) The Contractor shall be responsible to facilitate all factory functional tests to be conducted by the manufacturers of equipment at their premises before such equipment may leave their premises.

b) All equipment and material shall be jointly inspected by the Contractor, the Employer, and a representative from the Consultant, at the place of manufacture prior to delivery to the Contractors Works or to site.

c) Where manufacturing facilities are abroad, the Contractor shall make full provision, for travel and accommodation for the Employer's representatives (2 people) and Consulting Engineer (1 person) to attend and witness FATs in other countries.

d) On completion of the factory functional tests, the Employer shall either sign the test sheets (supplied by the Contractor) as having witnessed the satisfactory completion thereof, or hand to the Contractor a list of defects requiring rectification.

e) Upon rectification of the defects, if any, the Contractor shall arrange for the QA Inspector to certify satisfactory completion of factory functional tests for the switchgear and control equipment.

f) Acceptance by the Employer of satisfactory completion of factory functional tests in no way relieves the Contractor of his obligation to rectify defects, which may have been overlooked or become evident at a later stage.

g) The traction transformer shall be tested in accordance with specification IEC60076.

h) The auxiliary transformer tests shall be in accordance with SANS 780.

12.4 Site Acceptance Tests (SAT)

a) The Contractor's Test Engineer shall be responsible for the calculation of all relay settings as well as all other protection settings.

b) Testing and commissioning of the substation equipment will not be allowed to take place in a construction site environment.

c) On-site tests and subsequent commissioning shall not commence until all construction work has been completed.

d) Construction staff, as well as surplus material and equipment shall be withdrawn from site prior to the commencement of testing.

e) The Contractor shall be responsible to conduct functional tests on all equipment and circuitry to prove the proper installation and functioning thereof.

f) Proper operation of the protection system including the tripping and lockout functions as well as interlocking required shall be tested and to ensure conformance to specifications and designs.

g) The Employer shall arrange for his representatives and the PRASA Test Department Engineer to be present and witness the on-site tests.

h) On-site test shall include the following: -

1) Polarity tests on all CT's.

2) Ratio tests on all CT's.

3) Magnetising current of all CT's.

4) Knee point voltage test of CT's

5) Secondary injection of all relays.

6) After completing secondary injection tests, the Contractor shall perform primary injection tests to ensure correct operation of relay's and CT's polarities and direction of protection.

7) Trip testing of all relays shall be done for correct operation.

8) The functionality of all electrical circuitry shall be tested.

9) A rated power frequency voltage test on all MV equipment, at an appropriate voltage as specified by the manufacturer, for not less than one minute.

10) A rated power frequency voltage test on all small wiring at an appropriate voltage (2kV) as specified by the manufacturer of the switchgear, for not less than one minute.

11) Calibration and testing of HSCBs and relays.

12) Various tests on all Transformers as per IEC60076 (power transformers) and SANS780 (auxiliary transformers).

i) The Contractor shall supply all test equipment and instruments required to do all tests.

j) On completion of the on-site tests, the PRASA Test Department Engineer shall either sign the test sheets (supplied by the Contractor) as having witnessed the satisfactory completion thereof, or hand to the Contractor a list of defects requiring rectification.

k) Upon rectification of the defects, the Contractor shall arrange for the PRASA Test Department Engineer to certify satisfactory completion of on-site tests for the switchgear and control equipment.

l) Acceptance by the PRASA Test Department Engineer, of satisfactory completion of on-site tests in no way relieves the Contractor of his obligation to rectify defects, which may have been overlooked or become evident at a later stage.

m) All applicable outdoor and indoor tests and final commissioning shall be done by the Contractor.

12.5 Commissioning of Equipment

a) Commissioning will include the energising of equipment from the MV incomer circuit breakers to the MV track feeder switches, all low voltage equipment including the battery charger, the telecontrol equipment, control panels and the substation building distribution.

b) The Contractor shall prove the satisfactory operation of all equipment under live conditions.

c) On completion of commissioning, the Contractor shall hand the substation over to the Regional Engineer in terms of the relevant PRASA instructions and standard handover certificates.

d) The relevant responsible role players shall complete and sign the series of PRASA hand over documents – HOE, HOE1 & GI018.

e) The Contractor shall allow a period of at least three days between satisfactory completion of on-site tests and the commissioning of equipment.

f) During this period, the Regional Engineer and test staff will verify the operation of all protective relays and circuits.

g) The Contractor’s installation staff, and test Engineer shall be present during the verification to rectify any defects found.

12.6 Documentation

a) The Contractor shall supply and mount the substation power diagram drawing in an A1 size frame against the wall above the steel desk / cabinet.

b) The frame shall be made from wood and have a transparent cover.

c) The frame shall be mounted at a height where the drawings can be read when standing at the desk.

12.6.1 Data Packs

a) The Contractor shall compile and supply 3 complete sets of Data Packs. Each Data Pack shall include the following as a minimum:

1) Detailed operating and maintenance instruction manuals of all equipment, switchgear, relays, transformers and other electrical equipment. Documentation shall be hard copies as well as in electronic format on an electronic storage device (CD / Memory Stick)

2) Test results of all factory and site tests.

3) Certificates of Compliance

4) Handover documentation

5) As-built drawings of all the Contractor's drawings. The drawings shall be in hard copy format, electronic signed pdf format as well as in native electronic format of the software design package.

6) Marked (Red-lined) drawings of the Employer's design issued to the Contractor, shall be submitted for preparation of as-built drawings of the Employer's design.

b) Data Packs shall be submitted to the Employer for acceptance.

13 TRAINING

a) The Contractor shall provide training on all substation equipment supplied and installed (for repairs, planned maintenance and general operations) as part of the operational readiness and take-over of equipment.

b) Training shall include a theoretical as well as a practical portion. The theoretical portion shall be presented in a classroom environment. The practical portion shall be conducted at the substation with applicable references to the theoretical portion. The theoretical portion shall be conducted before the start of testing and commissioning.

c) The training shall be presented in two separate sessions as the full staff complement may not be released at the same time to attend training.

d) Provision shall be made for training of the following personnel numbers and grades:

1) 6 x Electricians
2) 4 x Technicians
3) 1 x Supervisor
4) 1 x Technical manager

14 EQUIPMENT SPARES LIST

a) The Contractor shall supply the following equipment spares as listed in Table 18 below.

Equipment Description	Quantity
Rectifier Diodes	16
Rectifier Diode Monitoring Card	1
Rectifier Attenuation Circuit Fuse	1
Rectifier Fan Motor	1
Fan Control Card Circuit Relays and Timers	1
Rectifier RC (“Snubber”) Circuit	10
Wave Filter Circuit Fuse	1
Control Panel IEDs per type used	1
110V DC Undervoltage Monitoring Relay	2
400V AC Power protection relays	1

65W 230V AC LED indoor luminaire	1
65W 230V AC LED indoor emergency type luminaire	1

Table 18: Required equipment spares.

b) In addition to the spares listed in the above table, Tenderers shall submit a list of spares recommended for maintenance of the substation.