



SITA PFC TECHNICAL SPECIFICATION

Version: 01

Date: 2021-09-21

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Approval

The signatories hereof, being duly authorised thereto, by their signatures, hereto authorise the execution of the work detailed herein, or confirm their acceptance of the contents hereof and authorise the implementation/adoption thereof, as the case may be, for and on behalf of the parties represented by them.

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1 Power Recording Evaluation

1. Accurate information on the SITA Centurion Facility power factor, load profile and reactive power profile were not available at time of this tender. SITA will provide load data as recorded by Vecto 1 power quality recorders to the Contractor after contract award.
2. The Contractor shall be responsible for:
 - (a) Evaluate the load data and determine the most optimal capacitor sizes to obtain a power factor of 0.96.
 - (b) Evaluate the harmonic information and determine if filter banks will be required
 - (c) Determine the size and parameters for the filter bank.
3. For the purpose of this Tender, the Tenderers shall use the sizes as stated in this document for pricing purposes. Any subsequent changes in capacitor sizes and the reactor sizes if required will be negotiated with the Contractor.

1.1 Detail Design

1. Detail design drawings shall be submitted for approval before manufacturing may start. The design includes interfacing detail with the:
 - (a) New switchgear for current transformers, measurements, protection, alarms and interlocking,
 - (b) Inter tripping to upstream and control,
2. Cable and termination schedules for all power, control and auxiliary supply cables shall be submitted as part of the detail design.

1.2 Factory Acceptance Testing

1. The medium voltage switchgear will be subject to a visual inspection and a mechanical operation verification at the Original Equipment Manufacturers premises.
2. The cost for the inspection at the OEM factory shall be provided as a separate line item and SITA will reserve the right to remove this requirement at their discretion.
3. In addition to the inspection at the OEM factory, the Contractor shall conduct a full integrated Factory Acceptance Testing in South Africa. This FAT shall include the switchgear, protection relays and PLC controller.
4. A detailed FAT plan discussing the FAT procedure, role-players, and showing all intended tests and durations shall be submitted for approval three weeks before the FAT.
5. Once the FAT plan is approved, the FAT dates shall be arranged with the attendees and agreed upon.
6. All Low Voltage wiring shall be point-to-pointed and marked off with a highlighter on the latest set of approved drawings. All changes shall be redlined during the FAT. The redlines shall be updated immediately after the FAT. All internal component model numbers shall be verified and marked off on the component list.

7. All interlocking features shall be demonstrated.
8. Test results from the FAT shall be submitted for approval before signing off and release of the equipment.

1.3 Installation

1. Installation of the PFC equipment, power cables, control cables, auxiliary cables and earthing is included. Any Civil work required to do the installation is included.

1.4 Commissioning

1. A Detailed SAT plan, detailing the various role players, SAT process, commissioning schedule and check sheets shall be submitted for approval 4 weeks before the actual SAT.
2. On completion of installation (after all the equipment have been installed and set up on site), Site Acceptance Testing (SAT) shall be carried out by the Contractor and witnessed by the Employer and the Project Manager. The SAT shall include cold and hot Commissioning.
3. All power cables need to be tested as required by SANS 10198 Part 13. Insulation test shall be done on all auxiliary and control cables before final termination. All combinations between cores and cores to earth shall be tested and marked off on a test sheet.
4. After termination, all cable cores shall be point-to-pointed and marked off on the cable and termination schedule.
5. After installation is complete, Control and Interlocking shall be function tested and proofed that all is operating according to design.

1.4.1 Pre SAT

1. The Contractor shall perform a pre-SAT to prove the functionality of the system before SITA appointed representatives are requested to witness the full-SAT tests.
2. The contractor's pre-SAT test results will be reviewed and accepted by ZSITA appointed engineers before commencing with the full-SAT tests.

1.4.2 Purpose of the SAT

1. The purpose of the cold-commissioning is to ascertain if the system is assembled and controlled according to the specified requirements, that all interfacing has been done and that the equipment & control system is ready for hot commissioning.
2. The Contractor shall provide experienced test personnel as well as an experienced and competent Engineer to undertake and supervise all the SAT commissioning tests.
3. The Contractor's Engineer shall work in conjunction with the Employer and Project Manager representatives on site and shall co-operate at all times with these representatives.

1.4.3 Visual Inspection

1. The purpose of the visual inspection is to identify any visual/mechanical defects. This includes the following:

- (a) To verify that no shipping damage has occurred.
 - (b) To verify that the equipment or system was assembled correctly.
2. The Contractor shall perform a visual inspection on the installed PFC equipment according to the Contractor's approved inspection lists. The Contractor will "back-punch" and sign-off all Contractors' findings before SITA representatives are requested to perform a visual inspection.
 3. The Client's punch-list will be "back-punched" and signed-off by the SITA representatives before the functional SAT testing can commence.

1.4.4 Cold Commissioning Requirements

1. The tests shall include, but not be limited to the following:
 - (a) Cable inspection and pressure testing.
 - (b) CT primary testing and mag curve testing
 - (c) Verification of schematic diagrams and cable & termination schedules.
 - (d) Verification of accuracy of nameplate information and application.
 - (e) Test reports & checklists.
 - (f) Testing of earth continuity to substation earth bar.
 - (g) Inspection and testing to ensure no loose connections on primary or secondary circuits.
 - (h) Check list for cleaning of panels.

1.4.5 Hot Commissioning Requirements

1. The Contractor shall provide experienced test personnel as well as an experienced and competent test Engineer to undertake and supervise all the commissioning tests. The test Engineer shall work in conjunction with the Employer's representatives on site and shall co-operate at all times with these representatives.
2. All operational tests will be verified by the Zutari and SITA representatives to ensure that the tests have been performed and the results were acceptable.
3. Final energisation authority and outage co-ordination will be the responsibility of SITA. If applicable, the Contractor shall submit a request for outage at least 14 days in advance for any further de-energised testing.
4. As a minimum, the following shall be included as hot commissioning tests:
 - (a) Verify the PFC -bank operation at normal voltage.
 - (b) Measure the current unbalance, monitor system voltages.
 - (c) Sign-Off documentation for the tests.

1.4.6 Rejection of Facility

1. If the contactors/vacuum breakers, capacitors, or retrofitted relays or any other work performed by the Contractor, fails to give satisfactory results under these above tests, the costs incurred in rectifying the defects on equipment and the execution of further performance tests shall be borne by the Contractor.

1.4.7 Documents and Drawings to be supplied by the contractor:

1. The Contractor will take note of the following requirements regarding documentation and drawings supplied on this contract:
 - (a) Warranty information of equipment.
 - (b) All drawings and manuals shall be provided in both hard copy and soft copy (on flash stick). Three hard copies and three soft copies shall be provided.
 - (c) The FAT & SAT deliverables shall be included.
 - (d) All maintenance, technical and operating instructions (all neatly bound) including wiring diagrams (properly referenced), associated layout drawings, test certificates and any other related information of all the equipment offered.
 - (e) The information provided shall include but not be limited to the equipment and structure dead weight, significant structure live loading, steel structure details, equipment external dimensions and the equipment impact loading.
 - (f) Drawings shall be in AutoCAD/MicroStation format and documents shall be in Microsoft Office format. The documents will be submitted for approval in PDF format.
 - (g) All design documentation and schematic diagrams shall be signed by the Contractor's Professional Engineer and be approved by Employer. All design related documentation shall be submitted for Review, Construction and As-built.
 - (h) Contact information of contractor and subcontractor involved in the project.
 - (i) The following drawing details must form part of the final design:
 - (j) Instruction drawings / manuals and descriptive literature for each of the supplied PFC equipment covering the installation, servicing, maintenance, connections shall be supplied.
 - (k) Cable and termination schedules.

1.5 End of Job Documentation

1. All drawings, cable and termination schedules, shall be updated to As Built status and submitted for approval as part of the End of Job documentation process.
2. Operating and technical manuals shall be supplied as part of the handover package.
3. Documents shall be submitted in the form of three sets of hardcopies and three sets in software format on a memory stick (flash stick).

2 Technical Specification

2.1 Technology

2.1.1 PFC Enclosure:

1. The capacitor bank and reactor shall be housed inside totally enclosed metal cabinets. The cabinets shall prevent any unauthorised touching or access to any life primary equipment while the doors are closed. The doors shall be equipped with the necessary interlocking measures to achieve unauthorised access to life equipment.
2. The cabinets shall be vermin proof, but still have sufficient ventilation holes and fans for cooling.
3. The cabinet size shall be such that it fits into the available floor space and will also effortlessly fit through the door without requiring adjustments or removal of the door. Please refer to the floor plan for proposed positions of cabinet.

2.1.2 Capacitor Banks

1. The capacitor cans shall be internally fused.
2. A balanced star – star configuration shall be used.
3. The capacitor shall comply with the requirements of the IEC 60871 and IEC 60931 where relevant. The technical specifications are provided in the Technical Returnable. They shall be rated for a system voltage of 12.1kV and shall be capable of sustaining the following conditions at ambient temperature (45°C) at an altitude of 1500 meters:
 - (a) $V_{cap} \leq 120\% \cdot (\text{Rated Voltage})$
 - (b) $V_{cap(RMS)} \leq 110\% \cdot (\text{Rated Voltage})$
 - (c) $I_{cap(RMS)} \leq 130\% \cdot (\text{Rated Current})$
 - (d) $Q_{cap(RMS)} \leq 135\% \cdot (\text{Rated Power})$
4. Where V_{cap} , I_{cap} and C_{cap} , are the Capacitor's operating values at any specific network condition.
5. The dielectric shall be all film and of the polypropylene film type and shall be filled with non-Toxic, non-Flammable, non-PCB capacitor oil. Each capacitor element shall have a separate internal fuse.
6. A permanently connected discharge resistor shall also be provided to reduce terminal voltage according to IEC60871.
7. Each capacitor unit shall have a scaled steel container with a suitable mounting bracket which can easily be fixed to the frame structures.
8. The container shall be built from stainless steel with welded seams, mechanically strong, rigid and hermetically sealed.
9. The container shall be designed to allow for expansion and contraction due to ambient and load conditions during the life of the unit.
10. The container (and new rack and enclosure if applicable) shall be painted according to Employer's Paint and Corrosion Protection Specifications.

11. In conjunction with the paint and corrosion specifications the Capacitor cans shall be painted and protected as follows:
 - (a) Preparation – Abrasive blast to SA 2.5
 - (b) Primer – Inorganic Zinc Silicate
 - (c) Intermediate – Epoxy
 - (d) Finishing – Epoxy Enamel
 - (e) Thickness - 200mm
12. The capacitor units shall be impregnated by non-PCB (non-toxic), non-poisonous, incombustible oil with a low viscosity, high chemical stability, high dielectric constant and shall cause no pollution to the environment. The characteristic of the oil shall be furnished in the technical bid.
13. Each unit shall have two bushings for terminal connections. The rating of the bushings should not be less than 12.1kV and suitable for series/parallel connections with other units. The bushings shall be of porcelain, suitable for intermediated polluted atmospheres having a creepage of not less than 31mm/kV.
14. The Contractor shall specify the capacitor unit's active power loss. The loss value of the discharge resistor and the tan-delta characteristic of the capacitor unit shall be supplied as part of the type test certificates.
15. The capacitor units shall be individually protected by internal fuses with a current limiting capability isolating the failed capacitor elements within the capacitor units, allowing the operation of the remaining elements within the unit.
16. The internal fuse shall be rated in such a manner that the fuse shall withstand the overcurrent rating of the capacitor unit, have an adequate thermal capacity to cater for the increased heating due to harmonics and current fluctuations and have a sufficient overvoltage capability to ensure reliable and safe operation under extreme transient overvoltage conditions during system transients and unbalance conditions.
17. The Contractor shall submit a detailed calculation for the number of internal fuse element failures to be considered for safe operation, and the setting to be adopted for unbalance protection relay alarm and tripping. The Contractor shall submit a table showing the number of units that can be lost per phase indicating the de-rating of the capacitor bank and the change in the harmonic tuning frequency.
18. The Contractor shall also provide the capacitor can case rupturing curve and the internal fuse characteristic on an over current time current curve.
19. A drip tray inside the enclosure shall be installed underneath the capacitors to ensure that any oil sweating or leaking out of the cans will be contained.
20. The Contractor shall clean the capacitor compartment and equipment including capacitor racks and contactor panels using electrical cleaner where required.
21. The final size of the capacitor bank is subject to a further study and load recordings. For the purpose of quoting, a base size of 1.25MVAR can be assumed.

22. The capacitor bank shall have a reactor with selectable taps for future increase in bank size. The circuit shall be tuned to 5th harmonic frequency.

2.1.3 Control Cables

1. The electrical and physical properties of low voltage and multi-core shall be PVC Insulated, PVC Bedded, SWA and PVC sheathed and rated 600/1000V. The cables shall have stranded copper conductors and shall be manufactured to SANS 1507-3.

2.1.4 General Material Specifications

1. All work shall be performed and completed in a thorough manner and shall follow industry best practices, notwithstanding any omissions from the Specification.
2. All work shall be performed by skilled tradesman in their various trades.
3. All material parts of equipment shall be made accurately to a standard gauge so as to facilitate replacement and repair.
4. All material shall be carefully packaged for shipment to prevent damage. All electrical equipment shall be shipped properly protected from moisture and dust.
5. The Contractor shall stay responsible for any equipment damaged, lost or stolen until the equipment/material is handed-over to SITA. Vibration monitors shall be used for road transportation.
6. Except where specified all iron and steel parts such as the mounting and support brackets of the capacitor rack and accessories, bolts, nuts, washers and base plates shall be hot dip galvanised after processes such as sawing, shearing, punching, filling, bending and machining are complete.
7. All equipment offered shall have an internationally accepted type/endurance test report not more than seven years old.

2.1.5 Earthing

1. The Contractor shall be required to earth the PFC equipment, to ensure the safety of personnel. The entire PFC installation shall be earthed and bonded. 2 x 70mm² insulated Copper conductor shall be used for earthing.

2.1.6 Labelling

All new equipment shall comply with the following general labelling requirements:

1. A visible nameplate stating name type and serial number.
2. Applicable operating and isolation procedures.
3. Danger notices are required to be erected at all designated entrances/chambers giving access to live equipment. Danger notices shall have red lettering on a white background or they may be pictorial as approved by SITA.
4. All labels shall be submitted for approval and shall be in English unless otherwise specified.
5. Terminal blocks or sections of terminal blocks shall be individually numbered and clearly labelled with the related circuit description

6. All cables shall be numbered at both end of the cable.
7. PFC Isolation signage including safe discharge times.
8. All switchgear labels, number plates shall be of synthetic resin with black letters on a white background fixed with screws/bolts onto a non-removable part of the panel. Stick-on or glued labels are not acceptable.
9. All labels shall be submitted for approval and shall be in English unless otherwise specified.

Table 1: Label Specifications

Function	Label size (mm)	Lettering(mm)
Main labels on panels, control panel and filter stage cubicles and similar equipment	125 X 50	20 X 1,5
Control and changeover switches and similar items	70 X 30	12 X 1,5
Relays and breakers	60 X 20	5 X 1
Other	35 X 15	5 X 1
	Or as approved by <i>Employer</i>	

2.1.7 Tuning Frequency

1. The Tenderer is required to offer current limiting/harmonic filter reactors to ensure that the inrush currents and capacitor bank switching transients are below acceptable switchgear limits. The Tenderer should calculate and provide the resultant tuning frequency to ensure that the plain PFC installation is not de-tuned to any low order characteristic harmonics. Both banks shall serve as harmonic filters.

2.1.8 Switchgear

1. Each Step shall be controlled by either a Circuit Breaker or a Fused Contactor capable of full load and full fault breaking. The requirement for the switchgear should be specified to the Switchgear Supplier. The switchgear should be rated for 30 000 or more operations.

2.1.9 Fault level

1. As specified in SITA Medium Voltage Switchgear Technical Specification.

2.2 Control Philosophy

2.2.1 Switchgear Panel

1. The control of the Power Factor Correction Equipment will be from the Switchgear Panel.

2.2.2 Internal discharge timer

1. The Switchgear Panel, will be programmed with a 5-minute internal discharging delay. Once a bank is opened, the same bank will not be closed within 5-minutes.

2.3 Protection

1. The protection of the Power Factor Correction Equipment will be from the Switchgear Panel.

2.4 Specifications and Standards

1. The following Specifications and Standards shall apply:
 - (a) All equipment offered in the tender, whether specified in detail or not, shall comply with the latest applicable reconditions of the South African Bureau of Standards and the latest applicable recommendations at the International Electro-Technical Commission (IEC).
 - (b) The following standards contain provisions, which through the reference in this text, constitute provisions of this specification. All standards are subject to revision and parties to the agreements based to this standard, are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.
2. In the event of conflict between documents invoked here, and the contents of this specification, the contents of this specification shall be considered to have preference.

SANS/IEC/Act	Description
SANS 1339	Installation, termination and testing of Cables before and after Installation
Act 85 of 1993	Occupational Health and Safety Act and Regulations
SANS 10142-1	Wiring of premises. LV
IEC 60871	Shunt Capacitors for a.c. power systems having a rated voltage above 1000V
IEC 60931	Shunt power capacitors of the non-self-healing type for a.c. systems having a rated voltage up to and including 1000V
SANS 1507-3	Manufacturing of LV PVC, SWA Control cables
IEC 60076-6	Power Transformers - Part 6: Reactors
IEC 60871-1	Shunt capacitors for AC power systems having a rated voltage above 1000V- Part 1: General
IEC 60871-3	Shunt capacitors for AC power systems having a rated voltage above 1000V- Part 3: Protection of shunt capacitors and shunt capacitor banks

IEC 61642	Industrial AC networks affected by harmonics – Application of filters and shunt capacitors.
IEC 60044-1	Instrument transformers – Part 1: Current Transformers
IEC 60815	Guide for the selection of insulators in respect of polluted conditions.
IEC 60273	Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V
IEC 60937	Insulated bushings for alternating voltages above 1000V
IEC 62271-1	High Voltage Switchgear and Control gear- Part 1: Common clause for HV Switchgear and Control Gear
IEC 62271-100	High Voltage Switchgear and Control gear- Part 100: High Voltage Switches
IEC 62271-102	High Voltage Switchgear and Control gear- Part 102: Alternating current disconnectors and Earthing Switches
IEC 62271-200	High-voltage switchgear and control gear Part 200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
IEC TS 61312-3 or SANS 61312-2	Protection against lightning electromagnetic impulse Part 3: Requirements of surge protective devices (SPDs)
IEC 60099-5 or SANS 600099-5	Surge Arrestors – Part 5: Selection and application recommendations
SANS 10199	The design and installation of earth electrodes
IEC 6071-1	Insulation co-ordination – Part 1: Definitions, principals and rules
IEC 60071-2	Insulation co-ordination – Part 2: Application guide
IEC 60168-am2	Test on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000V
IEC 61000-4-2	Testing and Measurement techniques – Section 2: Electrostatic discharge immunity test.
IEC 60529	Degrees of protection provided by enclosures
IEC 61000-4-18	Electromagnetic compatibility(EMC) – Part 4-18: Testing and measurement techniques
SANS 1339	Electric cables - Cross-linked polyethylene (XLPE) insulated cables for rated voltages 3,8/6,6 kV to 19/33 kV

SANS 1507-3	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1900/3 300 V) Part 3: PVC Distribution cables
SANS 876	Cable terminations and live conductors within air-filled enclosures (insulation co-ordination) for rated AC voltages from 7,2 kV up to and including 36 kV
SANS 10142-1	The wiring of premises Part 1: Low-voltage installations
NRS 026:1993	Battery charger - industrial type

2.5 Abbreviations and Definitions

Item	Description
°C	Degree Celsius
A	Ampere
AAC	All Aluminium Conductor
AC	Alternating Current
ADSS	All dielectric self-supporting
ANSI	American national standards institute
BCEW	Bare copper earth wire
BOQ	Bill of quantities
BS	British standard
CAD	Computer added drawing
cm	Centimetre
CT	Current Transformer
Cu	Copper
DC	Direct Current
EPC	Engineering procurement and construction
FAT	Factory acceptance test
GA	General arrangement
HDG	Hot dipped galvanized
HDPE	High density polyethylene
HF	High frequency
HMI	Human Machine Interface
HV	High Voltage
Hz	Hertz
IEC	International electrotechnical commission
IEEE	Institute of Electrical and Electronics Engineers
ISO	International standards organization
kA	Kilo Amperes

Item	Description
kg	Kilogram
kg/sqm	Kilogram per square metre
kl	Kilo litre
km ²	Square kilometre
kPa	Kilo Pascal
kV	Kilo Volts
LCD	Liquid crystal display
LED	Light emitting diode
m/s	Meter per second
MCB	Miniature circuit breaker
mPa	Mega Pascal
MV	Medium Voltage
MVA	Mega Volt Ampere
N/mm ²	Newton per square millimetre
NER	Neutral earthing resistor
NRS	National Reference Standard
ODF	Optical distribution frame
OEM	Original equipment manufacturer
OLTC	Online tap changer
ONAF	Oil natural air forced
ONAN	Oil natural air natural
OPGW	Optical Ground Wire
Pa	Pascal
PVA	Poli-Vinyl Acrylic
PVC	Polyvinyl Chloride
RTU	Remote Terminal Unit
RYB	Red-Yellow-Blue (phase rotation)
SANS	South African National Standard
SAT	Site acceptance test
SC	Standard connector

Item	Description
SCADA	Supervisory Control and Data Acquisition
TRFR	Transformer
UPS	Uninterruptible power supply
VT	Voltage Transformer
XLPE	Cross linked polyethylene