SPECIFICATION FOR THE ELECTRICAL INSTALLATION
SAMORA MACHEL POLICE STATION

PROJECT SPECIFICATION

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I N D E X

1. General Description and Extent of Work

This scope of work for the contract is the electrical installation at Samora Machel Police Station, comprising;

Main LV distribution equipment including switchgear, distribution boards;

Sub-main cable installation including all cable containment, fixings, terminations etc;

Lighting installation complete with all emergency lighting etc. including luminaires, lamps, controls, containment, final circuit wiring etc;

Lighting controls system;

Small power installation including supply, installation, terminations, and cable containment systems etc;

Lightning Protection, Earthing and Bonding installation;

Small Power and containment only for the Voice, Data and AV Systems;

Photo-Voltaic System;

Smoke Detection and Alarm System;

Closed Circuit Television System;

Access Control System;

Testing and commissioning;

Systems Training;

As Built Handover Documentation

This work is to be done in accordance with the contractor's installation programme and relevant division of work between trades as detailed elsewhere in this document.

2. Division of Work

2.1 Principal Building Contractor (PBC)

The Contractor will be responsible for providing the PBC with drawings indicating builders work requirements. Including but not limited to penetrations, plinths, co-ordination of supply points

2.2 Electrical Sub-Contractor (Contractor)

The extent of the work to be undertaken by the Contractor as part of this contract is shown on the contract drawings and listed in the Bills of Quantities for pricing.

2.3 Plumbing Sub-Contractor

Hot water cylinders/boilers will be provided, installed and connected up, mechanically and electrically by the Plumbing Sub-Contractor. The Contractor will bring an electricity supply to a position agreed with the PBC and terminate this supply in the isolator specified. The Plumbing Sub-Contractor’s electrician will be responsible for connecting up and wiring between isolator and hot water boiler.

The Contractor will be responsible for earthing hot and cold water piping and for all cross-bonding of the plumbing system. The Contractor is not responsible for the control and/or protection of the hot water cylinders/boilers.

2.4 Mechanical Sub-Contractor

HVAC equipment will be provided, installed and connected up, mechanically and electrically by the Mechanical Sub-Contractor. The Contractor will bring an electricity supply to a position agreed with the PBC and terminate this supply in the isolator specified. The Mechanical Sub-Contractor will be responsible for connecting up and wiring between isolator and equipment.

The Contractor will be responsible for the installation of cast-in / built in wireways to a position agreed with the PBC, for the installation of control wiring by the Mechanical SUB-Contractor.

The Contractor will be responsible for earthing and for all crossbonding of the mechanical system. The Contractor is not responsible for the control and/or protection of the HVAC equipment.

2.5 Security Sub-Contractor

Security equipment will be provided, installed and connected by the Security Sub-Contractor. The Contractor will bring an electricity supply to a position agreed with the PBC and terminate this supply in the isolator specified. The Security Sub-Contractor will be responsible for connecting up and wiring between isolator and equipment.

The Contractor will be responsible for the installation of cast-in / built in wireways to a position agreed with the PBC, for the installation of wiring by the Security Sub-Contractor.

The Contractor is not responsible for the control and/or protection of the Security equipment.

2.6 Voice & Data Contractor

Voice & Data equipment will be provided, installed and connected by the Voice & Data Sub-Contractor. The Contractor will bring an electricity supply to a position agreed with the PBC and terminate this supply in the isolator specified. The Voice & Data Sub-Contractor will be responsible for connecting up and wiring between isolator and equipment.

The Contractor will be responsible for the installation of wireways to a position agreed with the PBC, for the installation of wiring by the Voice & Data Sub-Contractor.

The Contractor will be responsible for providing a Voice & Data earthing infrastructure, terminating in earth-bars mounted to positions agreed with the PBC. The Contractor is not responsible for the control and/or protection of the Security equipment.

3. Contract Drawings

The tender drawings will become the contract drawings and will be revised, amplified and extended as necessary and in accordance with the development of the Architect's design.

The Sub-Contractor shall price for monitoring the Architect's and Structural Engineer’s drawings as issued to site, monitoring changes such as locations and swings of doors, windows, wall penetrations, etc. and for locating the electrical outlets and the installation generally to suit, as well as for informing the Engineer.

4. Cost Variations

Upon general revisions of an electrical drawing the relevant cost implications will be calculated, using the rates included in the Bill of Quantities. Where there are no Bills of Quantities rates the calculation will be based on rates generally applicable to the industry which will become the agreed “non scheduled item” rates. Scope of work changes will be calculated using rates included in the Bills of Quantities and the agreed “non scheduled item” rates. The cost of the

remeasured work and scope of work changes is to be agreed no a monthly basis. Variation Order No. 1 will be an omit of all contingency and provisional items.

Should the Contractor not agree with the rates of any non scheduled items or with the re-measurement quantities produced by the Engineer, he is required to advise the Engineer accordingly, within 2 (two) weeks of the date shown on the drawings and/or variation order, and to provide substantiation for the pricing revisions he requires, and the relevant costing details.

Under no circumstances will variation pricing be re-calculated at the request of the Contractor, after the 2 (two) weeks time period has expired.

Where it is imperative that the Contractor takes instructions from persons other than the Engineer, and acts immediately in the interests of the Employer to avoid abortive work or fruitless expenditure, it is mandatory for him to advise the Engineer telephonically of the cost implications, preferably before proceeding with the work but, at latest, within 24 (twenty four) hours of commencing the change. Failure to observe the foregoing (whether the instruction is given verbally or in writing) will result in the Contractor being held responsible for the cost of the variation work.

5. Testing, Setting and Commissioning

Comprehensive records of quality control, pre-testing, testing, pre-commissioning and commissioning documentation are to be included in the O&M documentation.

All records are to be dated, and signed.

Except where otherwise provided in the contract documents, the Contractor shall provide:

A test schedule for each section of the works or item of equipment/plant to be tested, giving the time, date and place of the test, detailing the test procedure, the type and number of tests to be carried out, and the type, make and serial numbers of all test instruments that will be used;

All labour, materials, power, fuel, accessories and properly calibrated instruments necessary for carrying out the tests.

The Contractor shall give 14 (fourteen) days notice, in writing, when any portion of the installation or plant is ready for testing.

In the event of the plant or installation not passing the tests, the Employer shall be at liberty to deduct from the contract price, any reasonable expenses incurred in repeating the tests.

The Contractor shall carry out preliminary tests necessary to satisfy himself that the plant, materials and equipment comply with the provisions of the contract and are in a suitable state to satisfy the requirements of the Specification. The Contractor is required to record these preliminary test results (in a manner to be agreed with the Engineer), and to submit one typed copy to the Engineer for comment, prior to the Engineer attending the acceptance tests.

If the Contractor fails to undertake the acceptance tests within a reasonable period of time, the Employer may arrange to have the tests performed by another party. All tests so made shall be at the risk and expense of the Contractor

The drawings and specifications contain details of any specific equipment, tests and setting requirements. In general, however, the following should be regarded as a minimum requirement:

Each circuit shall be checked for insulation resistance to earth and between phases and neutral, using a hand-cranked 500 volt megger;

The earth loop resistance and circuit resistance of each circuit shall be checked, using a null balance megger or earth loop tester;

The main earth system resistance shall be verified, using a hand- cranked null balance megger;

The on load volt drop and load balancing of all circuits and distribution boards shall be verified;

The earthing of all water and waste pipes shall be verified, using a null balance megger;

The lighting level in all areas shall be measured, using a suitable digital instrument;

The value at which all earth leakage units trip when tested at each outlet position in turn, shall be measured.

It is a requirement of this contract that the Contractor undertake all the above tests and submit the results in typed format on the RCE test report (1 per distribution board) to the Engineer. The test report is to be attached to the certificate of compliance.

The Engineer will subsequently request the Contractor to repeat all, or part, of these tests, during the final inspection prior to handover.

The Contractor shall set all fault protection overload devices to the prescribed settings/levels, and to list these settings in the as built drawings and manuals.

6. Approvals

The drawings, documents and specification indicate the type, size and make of equipment, materials and components required.

The Contractor will be required to supply, strictly in accordance with these requirements, unless otherwise approved by the Engineer.

Approval, in all instances, shall be taken as formal approval, in writing, by the Engineer. Verbal approval will not be recognized and the Contractor will be held responsible for any subsequent costs or fruitless expenditure involved.

7. Guarantees

The Contractor shall provide a twelve-month guarantee of all labour, materials and equipment supplied in terms of this contract.

The guarantee period shall commence from the date of practical completion of the whole project in terms of the Principal Building Agreement.

During the guarantee period, the Contractor will maintain (as per manufacturer's warranty requirements), without charge, all equipment supplied under this contract and, notwithstanding anything to the contrary, shall replace all components that fail, free of charge.

The guarantee is deemed to cover all items of equipment and materials, such as control fuses, lamps, starters, ballasts gauges, switches, relays etc. In the case of power fuses, the Contractor will only be required to replace these items free of charge where failure has occurred due to an inherent or latent defect in the installation.

When purchasing materials and equipment from suppliers, the Contractor shall obtain formal cessions of all guarantees covering the materials and equipment, from the supplier, in favour of the Employer. The Contractor should, therefore qualify all orders accordingly.

Where the Contractor is responsible for supplying transformers, distribution boards, M.V. switchgear etc. etc., be shall take ultimate responsibility for the guarantee of this equipment.

The Contractor will also be responsible for the guarantee of all components and equipment specified by name in the documents or as otherwise approved by the Engineer.

In the event of the Contractor objecting to certain types of equipment, component, manufacturer, or otherwise, this shall be stated at the time of tendering. The Contractor shall also indicate at least two alternatives that are acceptable generally and in terms of the 12 months guarantee requirement.

During the guarantee period, the Contractor will be contacted directly in regard to complaints or failures and shall in turn contact and direct the relevant supplier/manufacturer or his own staff, irrespective of whose ultimate responsibility it shall be to correct the situation.

8. Standards

The latest editions and/or amendments of the following Standards and Codes of Practice are applicable:

The South African National Standard (S.A.N.S.) Specifications, as applicable to this contract;

The Occupational Health and Safety Act, (Act 85 of 1993) as amended;

The latest edition of the S.A.N.S. 10142 Code of Practice for the Wiring of Premises;

I.E.C. Standard Specifications and Codes of Practice, where the S.A.N.S. and B.S.S. equivalents are not available;

The British Standard Specifications (B.S.S.) and Codes of Practice, where the S.A.N.S. and I.E.C. equivalents are not available.

9. Materials and Equipment

Wherever possible, material and equipment shall be of South African manufacture and of the same make and type throughout the installation.

Where materials and equipment are specified by name, make or type number, alternatives will not be considered, unless it is to the Employer's advantage.

10. Equipment Delivery

The Contractor shall place orders timeously for all materials and equipment. The responsibility for verifying delivery times of items specified rests solely with the Contractor

In this regard, the Contractor's attention is directed to long lead cabling, distribution board and luminaires.

11. Drawings, Samples, and Operating Manuals

11.1 Installation and Shop Drawings & Samples

Installation and shop drawings are drawings, diagrams, illustrations, Schedules, performance charts and information brochures which are prepared by the Contractor or his suppliers, to illustrate some detailed engineering or installation aspect of the works.

Samples are physical examples, provided by the Contractor or his representative and suppliers, illustrating the intended quality and type of materials, equipment and workmanship, and to establish standards by which the works will be judged.

The relevant sections of the specifications indicate specific installation/shop drawing and sample requirements. The Contractor shall allow for the production of such additional drawings and information as may be necessary, from time to time, to illustrate compliance with the specifications, installations, method/procedure, or engineering aspects.

Samples and mockups will be required for all aesthetically prominent accessories or installations.

The Contractor shall inspect all drawings, including structural and other services, installation, shop and design drawings, pertaining to the works, and shall make the

necessary allowance in the tender price for the minor extras and omissions which might occur as the result of these final detailed co-ordinated installation and shop drawings.

The Contractor shall review, stamp with his approval and submit with reasonable promptness, and in orderly sequence so as to cause no delay in the work, all drawings and samples required by the contract documents.

At the time of each submission the Contractor shall inform the Engineer, in writing, of any deviation in the installation and shop drawings or samples, from the requirements of the contract documents.

By submitting installation and shop drawings and samples, the Contractor thereby represents that he has determined and verified all field measurements, field construction criteria, materials, catalogue numbers and similar data, and that he has checked and co-ordinated each installation and shop drawing and sample, with the requirements of the works and of the contract documents.

The Engineer will review drawings and samples with reasonable promptness, but only for conformance with the design concept of the project and the contract documents.

The Contractor shall make any corrections required in terms of the Specification, and shall re-submit the required number of corrected copies of drawings or samples. The Contractor shall direct specific attention, in writing, on re- submitted installation and shop drawings, to revisions other than the corrections required by the Engineer on previous submissions.

The Contractor shall submit drawings for review, at least 6 (six) weeks in advance of the required ordering, manufacturing or installation dates.

The reviewing of drawings or samples by the engineer shall not relieve the Contractor of responsibility for any deviation from the requirement of the contract documents including compliance with program, responsibility for errors or omission in the drawings or samples, etc.

11.2 Record Drawings

Record drawings shall be maintained on a current basis as work progresses. Site inspections shall include a review of the record drawings, for the area or equipment inspected.

The Contractor shall be provided with a set of prints to be kept by him on site and dimensioned by the Contractor showing the exact locations of all electrical equipment, cast or built in conduits, sleeves etc.

The positions of all cables, sleeves, conduit, service routes, joints etc. shall be dimensioned on a triangular basis.

Prior to commissioning and handover, the Contractor shall provide a complete set of record drawings, cross-referenced to the Operating and Maintenance Manuals where necessary, and in sufficient detail to enable the employer to carry out proper maintenance, and to facilitate subsequent alterations and additions to the system.

Drawings, Legends, Schedules, Diagrams, intended for framing and wall-mounting, shall be of the fade-free, black ink on a transparency, or photographic type.

11.3 Operation/Maintenance Manuals

The operation and maintenance manuals shall contain all information required to enable the safe and efficient operation and maintenance of all systems associated with the building.

Prior to commissioning, the Contractor shall submit a draft copy of the indexed, loose-leaf manuals, containing complete operating and maintenance instructions for all mechanical and electrical systems specified under this contract.

Manuals shall be hard covered, at least A4 in size, and must be provided with transparent plastic over-covers and reinforcing ring binders, for each page.

Post commissioning and handover, the Contractor shall provide three copies of indexed, loose-leaf manuals, and an electronic copy (CD/DVD) containing complete operating and maintenance instructions for all mechanical and electrical systems specified under this contract, including comprehensive testing and commissioning records.

All manuals must lie flat when open.

Content shall be printed. Photocopies from product brochures will not be accepted. Only information relevant to this contract should be included

The scope of content should include:

- Contractors and specialist supplier details
- Emergency contact details
- Health and safety documentation
- Project Systems description
- Modes of operation including emergency procedures and call out personnel
- Maintenance instructions and schedules and fault finding advice
- Asset register
- Equipment schedules
- Advice on disposal
- Software schedules and licenses
- Parts identification and recommended spares
- Guarantee information with work/inspection/maintenance required to ensure guarantees are not nullified
- Manufacturer’s technical literature.
- Test Certificates - Refer to RCE “Typical Test Report”
- Commissioning data
- Certificates of compliance per distribution board
- Statutory certification
- Copies of standard RCE A4 Distribution Board Legend cards.
- System training records
- Record drawings
- Modification information

Note: Certificates of compliance to include the relevant RCE Test Certificate and legend card.

11.4 Logbooks

Logbooks shall be provided in each plant room, and must be at least A4 in size, typed and feint-line ruled, to provide the following columns and column headings on each page:

- Date.
- Description of Work.
- Artisan's Signature.

Time Spent.

The logbooks shall be provided prior to commissioning and start-up of the plant, are to be kept up-to-date by the Contractor, from date of handover of the plant.

All logbooks must lie flat when open.

12. Training

Prior to handover, the Contractor shall conduct comprehensive training sessions for each installed system to minimum three client representatives to enable proper running and maintenance of the installed systems.

Proposed training times shall be submitted by the Contractor at least two weeks prior to the proposed date, and shall be agreed upon by both parties.

The training shall include, but not be limited to the following:

Systems set-up and configuration;
Modes of operation of the system;
Systems preventative maintenance and trouble shooting.

Training sessions shall be documented and submitted with the handover documents for reference.

Separate training sessions shall be documented for each portion of the works.

13. Registered Personnel

The Contractor shall have at least one installation electrician in full time employment assigned permanently to this project.

The Contractor shall appoint an approved inspection authority who shall certify compliance from commencement to commissioning of the electrical installation as per the requirements of section 5.5 of the Certificate of Compliance.

Proof of these aspects shall be submitted with the completed tender document.

14. Service Conditions

Normal Service	: As scheduled
Maximum ambient temp.	: +40°C
Minimum ambient temp.	: -5°C
Humidity	: Max. Humidity: 95%
Rain fall	: high in summer months, low in winter months.
Atmosphere	: Corrosive due to wind blown salt spray

All equipment and materials shall be suitable for the climatic and environmental conditions pertaining to coastal conditions.

Metalwork exposed to sea water, salt water vapour and the weather shall be stainless steel or protected against corrosion to the approval of the engineer.

Contact between dissimilar metals shall be avoided. As a minimum, the following electrode potentials shall not be exceeded.

for connections exposed to the weather, salt water vapour or salt water, 0,25V.

for connections of interior parts subjected to condensation but not contaminated by salt, 0.50V.

15. Electrical Supply System

The Supply Authority Electricity Grid consists of system voltages of 132kV; 11kV; 400V 3-phase CNE and 230V single phase (50Hz)

15.1 Supply Technical Data

System Voltage	: 11,000V ±10% / 400V ±10% as applicable
Rated Frequency	: 50Hz
Phase rotation	: 3 phase, RWBR (clockwise)
Design SSCC	: 20kA at 11 kV

16. Electricity Supply Authority

The Contractor shall liaise with the Supply Authority to ensure that all applications to commence work are submitted, fees paid and local requirements complied with.

The installation shall comply with the Supply Authority's requirements in all respects and good engineering practice.

17. Earthing

All cable containment exposed metal work is to be earthed and earths are to be continuous for the length of the run and include all bends.

All circuits are to be provided with a separate earth wire as specified or as per SANS 10142 as a minimum requirement.

Circuit earths and earth loop impedance must all be verified and the Engineer informed so that satisfactory operation of protection devices can be checked.

Earthing conductor system

The total earthing system of any electrical installation shall be in accordance with SANS 10142. Earth conductors shall be stranded copper with green PVC insulation installed on a radial arrangement from each distribution board, with no T joints or interconnection of circuits.

17.2 Sub-Distribution Boards

A separate earth connection shall be provided between the earth busbar in each sub-distribution board and the earth busbar in the Main LV distribution board. These connections shall consist of PVC insulated stranded copper conductors installed along the same routes as the supply cables or in the same conduit as the supply conductors.

17.3 Ring Mains

Common earth conductors may not be used where various circuits are installed in the same wiring channel.

17.4 Clean Power Earthing

Earthing for the reticulation of clean power circuits shall follow the following rules:

i) All sub-distribution boards containing clean power circuits shall be provided with a clean earth bar, completely insulated from the rest of the board and domestic earthing systems.

ii) PVC-insulated earth conductors shall be used throughout for the clean power system. These conductors shall be fixed to the clean earth bars by means of lugs and bolts, always ensuring that the connections are completely insulated from domestic earth components.

iii) Clean power earth conductors shall always be installed in radial fashion and no earth loops shall be formed.

iv) The Contractor shall ensure that complete isolation is maintained, at all times, between clean earth conductors and terminations, and the domestic earth system, particularly at equipment boxes and sockets.

v) The Contractor shall also ensure that connectors, plug boxes, female sockets, etc., used for clean power circuits are adequately designed to provide complete isolation from the domestic earth system.

vi) It will be expected of the Contractor, as part of hand over procedure, to demonstrate adequate isolation, (better than 1 Ohm), between all clean earth points and the remainder of the domestic earth system.

18. Bonding

The Contractor shall cross bond and earth all metallic services in the vicinity of electrical equipment and circuiting including hot and cold water pipes, waste and drain pipes, ceiling grids, cable trays, hand rails etc. The earth loop impedance to the furtherest point from local distribution board of all metallic services shall be checked and submitted to the Engineer for approval.

All steel pipes shall be connected with solid 12mm x 0.8mm perforated or solid copper strapping to the nearest distribution board. The strapping shall be fixed to the pipe work with brass nuts and bolts and against walls with brass screws at 150mm centres.

In all cases where steel pipes are positioned within 1.5m of distribution boards, an earth connection consisting of copper strapping shall be installed between the pipe work and the board. In vertical building ducts accommodating steel pipes and electrical cables, all pipes shall be earthed at each distribution board.

19. Lightning Protection

The Contractor shall arrange for the specialist lightning protection contractor to monitor the bonding of the column and roof steel. This contractor shall provide the necessary earthing spikes/conductors as indicated and shall complete the lightning protection system in accordance with the relevant SANS code of practice and the contract drawings.

20. Surge Protection

When specified the surge protection is to comply with the following

Protection against lightning:	Class 1 – 25 kA, (10/350 µS) impulse current waveform protection device on all phases and neutral at the power supplies source to equipment at 400/230 Volts. Connection to be suitable for TNS earthing systems.
Protection against surges:	Class 2 – 20 kA (8/20 µS) surge current waveform protection device on all phases and neutral power supplies to equipment

	at 400/230 Volts in local DB. Connection to be suitable for TNS earthing systems.
Protection against surges:	Class 3 – 5 kA (8/20 µS), surge current wave and (1.2/50 µS) voltage waveform and Voltage peak of 1.5 kV on all phases and neutral power supplies to equipment at 400/230 Volt within 10 metres of equipment.
Internal Equipment Protection:	Surge protection to electronics equipment shall be provided as required by the equipment manufacturer to be suitable for co-ordination and cascading with the above protection.

21. L.V. Distribution Boards

21.1 Scope

The specification covers all low voltage Switchgear and control gear assemblies.

21.2 Standards Requirements

Low Voltage Switchgear and Control Gear Assemblies, are to be manufactured in accordance with SANS 1473–1 (as amended), SANS IEC 60439-1 (as amended) and SANS 10142-1 (as amended) specifications.

With regard to the above specification the following applies to the manufacture of the distribution boards.

21.3 Board Construction and Design

21.3.1 Construction

a) Floor standing multi cubicle type assembly/unless otherwise specified

b) Stationary indoor installation

c) IP54 unless otherwise specified

d) Form 2b unless otherwise specified (Terminals in cable chamber for outgoing conductors, per functional unit, to be individually shrouded with 5 mm thick transparent polycarbonate cover)

e) Naturally ventilated

f) Physical Dimensions

1)	Dimension	as shown on layout drawings
2)	Cable entry	Top entry via a 300 mm wide cable entry cover along the full length of the distribution board

21.3.2 Electrical Characteristics

a)	Operational Voltage	400 Volts phase to phase 230 Volts phase to neutral/earth
b)	Insulation Voltage	1000 Volts phase to phase 600 Volts phase to earth
c)	Impulse Withstand Voltage	2 500 Volts phase to phase

d) Rated short time withstand current (fault level) as shown on the single line diagrams

e) Rated peak withstand current is to be in accordance with table 5 in SANS IEC 60439-1.

f) Cross sectional area of protective conductors with regard to thermal stresses due to current of short duration are to be based on a duration of 0.1 seconds.

g) Earthing system : TN-S

Note: Rated currents of circuits and electrical equipment as shown on the drawings

DO NOT take into account the derating of such circuits and electrical equipment due to temperature rise.

21.3.3 Environmental Conditions

a) Maximum air temperature (at any point) within the distribution board is not to exceed 10°C above ambient of 40°C maximum and an average of 35°C over a 24 hour period.

Note: Should the heat rise within the distribution board exceed the above limits due to the limitations of the room size etc. tenderers are to advise the anticipated heat rise in each cubicle.

b) Relative humidity – As per clause 6.12.1 in SANS IEC 60439-1.

c) Pollution degree 3 applies

d) Installed at sea level/inland as applicable

21.3.4 Testing

a) Tenderer to advise whether distribution boards are fully type tested, partially type tested or specially type tested assemblies. Compliance/non compliance is to be indicated.

b) Routine tests are to be carried out at the place of manufacture and repeated on site.

21.4 General

The following general requirements are to be complied with provided they do not conflict with the above requirements. Any conflicts are to be advised by the tenderer at the time of tender.

21.4.1 Enclosures

Enclosures for distribution boards and control panels shall be wall or floor mounting as indicated, shall be engineered to accommodate the necessary equipment specified and to comply with this specification.

The minimum thickness of the chassis and partition metal work shall be 1,5 mm for assemblies not exceeding 0,75 m² or 2 mm for larger panels. Thicker sheets shall be used for very large panels and where the weight of the equipment would cause buckling or vibration.

Lap welding of panels and boxing of sections, is unacceptable unless specifically approved. Bolted stiffening channels and braces are acceptable.

Completed sheet metal enclosures shall be free, internally and externally, from burrs, sharp edges and blemishes. A removable steel base frame shall be allowed for floor mounting boards. Removable lifting eyes shall be provided for heavy panels.

All switchboard covers/doors are to be of the hinged type. Covers which have to be lifted out of position are unacceptable.

Main switchboards and motor control panels are to be extendable in both directions.

Unless otherwise specified, all wall mounting boards shall be front access only, and shall be manufactured in two parts :

a) a rear chassis, either built into or attached to, the supporting wall;

b) an outer panel, secured to the chassis on completion of the work, and readily removable from it.

The chassis will be manufactured from zinc coated mild steel, zintex steel, other approved method of electro galvanised mild steel or 3 CR12. The chassis shall have suitable knockouts, along the top and bottom panels, for the terminations of all conduits, in not more than two rows. A feeder cable entry knockout shall also be provided, suitable for the feeder cable rating indicated on the drawings.

The outer panel, secured to the chassis by means of adjustable bolts, carrying the equipment trays, the busbars and the wiring harness, is to be securely supported.

21.4.2 Painting

Tenderers are to price the following paint specification as a minimum requirement :

The surface is to be prepared prior to painting by phosphatisation cleaning/degreasing treatment. The surface is then to be coated with an etching primer, followed by a base coat and an epoxy polyester powder coating to a minimum thickness of 110 µm.

The colour of the finishing coats shall be decided at the time of shop and installation drawing approval.

Any on site paint damage to be treated and touched up immediately.

21.4.3 Accessories

Hinges shall be of the brass lift off type. Door/cubicle catches shall be of the Barker Nelson type provided these meet the standard specification. Rear covers to be hinged and locked by electrical panel key and shall not be secured by screws or bolts. Weld-on type hinges and door locks will not be acceptable.

Door opening, closing, latching and de-latching operations shall be smooth and quick, whilst ensuring proper compression of the sealing gaskets without damaging or marking the paintwork or corrosion-resistant surface of the Board.

Sealing strips and gaskets shall be made of durable, non-hardening synthetic rubber or other suitable material. Care must be taken to ensure that even pressure is exerted along the entire length of the gasket, and that neither deflection nor buckling of panels occurs when the gasket is compressed.

For switchboards intended for use indoors, and for external use in areas remote from the coast (100 kms), bolts, nuts and washers shall be cadmium-plated, electro-plated or galvanised.

For switchboards intended for use outdoors or in coastal areas e.g. Durban area, the minimum corrosion specification for all nuts, bolts and washers shall be 316 L stainless steel. Busbar bolts must be high tensile steel type, complete with lock-nuts and lock washers. To avoid damage to the paintwork, screws, bolts, door locks, etc., must not be in direct contact with painted surfaces.

The use of self-tapping screws is unacceptable. All tapped holes in metalwork shall have a minimum tapped thread length equal to the diameter of the tapped hole. All concealed/inaccessible nuts are to be of the permanently captive type. The electrogalvanised caged nut is unacceptable.

Tapped holes shall have the exposed metalwork protected against corrosion by the application of a suitable inhibitor over the tapped area, such as Tectyl or copperslip.

21.4.4 Cabling, Wiring and Busbars

The main busbars (including the neutral) shall be installed together along the top (wherever possible) of the switchboard, and along its full length. Busbars connected to C.B. stubs are to be sized and connected in accordance with the C.B. manufacturer's requirements.

All outgoing circuit breakers on main switchboards shall be connected to vertical busbar droppers with copper busbar tails. Busbar tails to be shrouded.

Busbar droppers from the main busbars to be segregated from cable chamber.

All outgoing circuit breakers on main switchboards shall be fitted with copper busbar tails to facilitate cable terminations in the cable chamber and not on the circuit breaker. Busbar tails shall be shrouded.

Spare spaces shall be fitted with copper busbar tails (load and supply side) for future connection.

Phase identification shall be Red, White, Blue, reading top to bottom, left to right, and from front to back, when facing the front face of the board.

The insulation of the busbars and conductors shall not be stripped beyond the leading edge of the connection /terminal in which it has to be accommodated. Stripping shall be carried out without damage to the conductor, by means of a cable stripper.

Crimping lugs and ferrules shall be used for connection into equipment not provided with screw-type compression terminals. All crimps of conductors 35 mm² and above are to be subjected to test crimps.

All wiring and terminations shall be readily accessible. Under no circumstances may terminal rails be fixed to the D.B. tray or the side panels of the D.B. tray or the side panels of the D.B., or located close to live terminals, or positioned behind wiring run to equipment in the board.

The wiring shall be carried out neatly, along perpendicular lines, and it shall be accommodated in enclosed wiring channels.

The wiring shall not preclude the removal of, nor block the access to, any component.

Insulated conductors shall not be bunched together in order to avoid heat accumulation within the core of the bunch. If bunching of conductors in unavoidable, the conductors should be de-rated in accordance with the relevant Table of the S.A.N.S. 10142 as amended, Code of Practice, control and indication for the Wiring of Premises or BS7671.

Sub-distribution circuits protected by HRC fuses need only be rated for the maximum prospective asymmetrical fault level possible when the largest fusible link is installed in the fuse base.

The minimum conductor area of any wiring shall not be less than 2,5 mm² and no hard drawn copper wiring is to be used within the board. All wiring is to be of the tinned, fine stranded flexible type.

All wiring within boards is to be insulated. No B.C. wiring is permitted for either phase neutral or earth wiring; the earth bar being the exception. Single phase

distribution boards shall be wired in red and black PVC insulated conductors. Three phase distribution boards shall be wired in red, white and blue, black and green PVC insulated conductors.

Control panels and motor contactor boards shall be wired on the power side, with red, white and blue insulated conductors. Live control wiring shall be orange. Unearthed and DC control wiring shall be grey.

Neutral connections shall be black, this colour must not be used for any other connection. Earth wiring shall be insulated green, or striped green-yellow, conductors.

Cable colour coding shall be discussed with the Engineer when foreign equipment, wired to different standards, is to be incorporated in the installation.

21.4.5 General and Installation Arrangement Details

Large air circuit breakers and switch fuse units shall not be positioned at high level, unless facilities are provided to assist maintenance staff in withdrawing these units.
The arrangement shall be such that sufficient space exists between adjacent items of equipment for the installation of incoming and outgoing conductors and for heat dissipation.

Moulded case circuit breakers in main switchboards shall be mounted side on.

The Board shall be of sufficient dimension to allow the installation of all equipment specified and any future equipment indicated on the drawings, without unduly restricting the access to, and the clearance between, the various rows.

Particular attention shall be paid to the accommodation and bending of incoming and outgoing conductors within the enclosure, and the working space necessary for making off the cables, installing the lugs and connecting into the equipment. Suitable provision shall be made for vermin-proofing the cable entries and earthing the armouring. Busbar bending radii shall not be less than the minimum permissible for the thickness of busbar being used.

Control/metering fuses or circuit breakers shall be base mounted on the relevant busbar. Unprotected wiring may not be run off busbars or from C.B. power terminals to remote fuses/equipment. These fuses/circuit breakers shall be easily accessible and completely safe for maintenance staff to service and repair.

Ring type current transformers shall be insulated from the busbars and fixings making electrical contact with the bar must be total shrouded and locked into position with lock nuts. Current transformers around different phase may not touch each other. A minimum clearance of 50 mm is to be maintained between adjacent CT’s, and between CT's and adjacent busbars.

In general, main switchboards shall be arranged such that it is possible to make off and terminate cables and install additional switches, without any risk of coming into contact with live conductors.

Main switchboard panels shall be of uniform width, with not more than two size variations, i.e. 600 mm and 750 mm.

Single phase sections of three phase boards shall be separated from each other. Lighting on the left-hand side and single phase power circuit on the right-hand side or lower section or top section. Three phase power circuits are to be grouped together and be remote from the above single phase circuits. Extra space for future circuits shall be allowed for, as specified. Covers are to be provided over spare spaces. Similar provision for future circuits shall be made on the busbars, neutral and earth bars.

All parts of the distribution board metalwork shall be electrically continuous, and a suitable stud shall be provided for the earthing of the enclosures.

Particular attention shall be paid to the earth continuity of removable and hinged access panels, particularly those carrying supervisory and control equipment. flexible copper straps may be used for the purpose of ensuring the earth continuity between the board and the panels.

A removable facia cover shall be provided behind a hinged door through which toggles and other operating handles shall project and fixed by means of suitable fasteners. This plate shall be supported so that its replacement and removal is easily achieved without having to manoeuvre the plate so that fasteners can engage.

All wiring terminations and connections shall be made behind the facia plate and shall not be accessible without its prior removal. The board shall be designed so that the switch toggles, instruments, etc., are easily accessible to operators of average height, (i.e. upper edge of equipment shall not be higher than 2 m or lower than 0,25 m above floor level) unless otherwise specified.

LV main and sub-distribution boards and motor control panels shall be erected, installed and commissioned in the positions shown on the drawings.

During transport to site and installation, the boards shall be protected against mechanical damage and vibration.

Boards shall not be moved on to site, nor be installed, until all building services and finishing trade work has been completed in the room or vicinity of where the boards are to be installed. If boards are installed prior to this the entire unit in each case must be shrouded in PVC bubble type wrapper.

The boards shall be installed in such a manner as to facilitate extensions, maintenance, testing and repair work, with easy access to cable entries/terminations, current transformers, potential transformers, small wiring terminal boards and relays, and busbar connections.

21.4.6 Installation/Shop Drawings and Samples

Drawings of all equipment shall be submitted to the Engineer, in triplicate, for approval, at least 6 (six) weeks in advance of the latest manufacturing commencement date.

As a minimum, the shop drawings shall indicate:

a) Busbar and dropper bracing and support details, including actual or type test certificate from an accepted testing station, in substantiation of short circuit capacity and withstand capability of the system.

b) Temperature rise calculation for each cubicle based on all circuits are equipment (including space for future) to be installed in the cubicle.

c) Main and distribution busbar section and size including selection/sizing criteria and calculations in substantiation of the full load rating (including derating for temperature rise limits and sizes/connection details to circuit breakers).

d) Equipment selection to achieve full load rating requirements shown on drawings to accommodate derating for temperature rise.

e) Time current characteristics of the incoming and outgoing circuit breakers and switch fuse units on transparent drawing paper to facilitate super position of the characteristics on one another.

f) Fully dimensioned and detailed equipment layout/front elevation and sectional side elevations.

g) Details of construction, compliance with IP rating, access and cable termination facilities etc.

As a minimum, the dimensioned installation drawings shall indicate:

h) Position of switchboard relative to cable trenches, cable trays, adjacent wall and equipment.

i) Surrounding clear space between walls and adjacent equipment for access and maintenance purposes.

j) Cable entry details and cable routing and crossover aspects when entering the board.

k) Details of supports across trenches and the interface between the cable trench covers and switchboard.

The record drawings and manuals shall comprise the relevant final as approved and installed installation and shop drawings. The maintenance and fault finding manuals shall be explicit, shall cross-reference to the drawings, schematics and control logic diagrams, and shall provide full maintenance details, requirements, methods and schedules for each and every type of device employed. Furthermore, the manual shall contain spare parts lists and numbers, for all equipment.

21.4.7 Typical Arrangement Drawings

Arrangement drawings are included as a guide, and illustrate the desired arrangement concepts. In pricing and engineering the boards, cognisance must be taken of the actual constraints imposed due to the size and type of equipment to be accommodated, the location of the board within the building, the manner of installation, number and size of the circuits, cable entries, access and routing limitations within the building.

REV.	DESCRIPTION	BY	DATE	CHKD.

ENGINEER
PROJECT No.
DRAWN DATE: Jul 11
DRAWING No.
SHEET: 1 of 1
SCALE: nts
PAPER SIZE: A3
REV. 0
CHKD.
File Name :
LYT:

PROJECT:
Drawing Standards

DRAWING TITLE:
Main LV Panel
Typical Layout And Details

IBUYA Consulting Engineers
"POWERING DEVELOPMENT"

21.4.8 Labelling

All labels are to be of the traffolite type and fixed to the board with nuts and bolts. All internal control and indication components are to be labelled and correspond to the as built drawings.

21.4.9 Trench Boxes

Wherever necessary, cable trench covers must be cut to size and replaced to fit snugly around floor standing boards.

21.5 Witnessing of Tests

The engineer reserves the right to be present at any of the tests specified (factory or site tests). The Engineer shall be notified in time (2 weeks notice) to enable him to attend the tests should he wish to do so.

The tenderer shall replace any part of the Distribution Board should it be found not compliant with the specification, during tests or inspections. The replacement of any parts shall be for the Tenderer's cost.

No Distribution Board shall be dispatched from the manufacturer's works without the Engineer's approval of its testing and overall quality.

21.6 Test Certificates

Two copies of test certificates shall be supplied to the Engineer prior to the equipment being delivered to site.

A copy of the factory and on site test certificates shall be incorporated into each maintenance manual.

A copy of the As Built shop drawings (including any on site modifications) and wiring diagrams shall be incorporated into each maintenance manual.

SCHEDULE OF TESTS FOR COMPLIANCE WITH FULLY, PARTIALLY AND SPECIALLY TYPE TESTED ASSEMBLIES TO BE COMPLETED BY TENDERER, SUPPORTING DOCUMENTATION TO SUBSTANTIATE EACH OF THE FOLLOWING TESTS ARE TO BE SUBMITTED AT TENDER

No	Characteristics to be checked	Type Tested Assembly (TTA) Tenderer to confirm compliance with the following type tests		Partially Type Tested Assembly (PTTA) Tenderer to confirm compliance by type test, calculation or visual inspections		Specially Type Tested Assembly (PTTA) Tenderer to confirm compliance by type test, calculation or visual inspections	
1	Temperature rise limits	Verification of temperature rise limits by test	YES	Verification of temperature rise limits by test or extrapolation from type-tested ASSEMBLIES	YES	Verification of temperature rise limits by test or extrapolation from type-tested ASSEMBLIES	YES
			NO		NO		NO
2	Dielectric properties	Verification of dielectric properties by test	YES	Verification of dielectrical properties by test according to 8.2.2 or 8.3.3, or verification of insulation resistance according to 8.3.4 (see No. 11)	YES	Verification of dielectrical properties by test according to 8.2.2 or 8.3.3, or verification of insulation resistance according to 8.3.4 (see No. 11)	YES
			NO		NO		NO
3	Short-circuit withstand strength	Verification of the short-circuit withstand strength by test	YES	Verification of the short-circuit withstand strength by test or by extrapolation from similar type-tested arrangements	YES NO	Verification of the short-circuit withstand strength by test or by extrapolation from similar type-tested arrangements	YES
			NO				NO
4	Effectiveness of the protective circuit	Verification of the effective connection between the exposed conductive parts of the ASSEMBLY and the protective circuit by inspection or by resistance measurement Verification of the short-circuit withstand strength of the protective circuit by test	YES	Verification of the effective connection between the exposed conductive parts of the ASSEMBLY and the protective circuit by inspection or by resistance measurement	YES	Verification of the effective connection between the exposed conductive parts of the ASSEMBLY and the protective circuit by inspection or by resistance measurement	YES
			NO	Verification of the short-circuit withstand strength of the protective circuit by test or appropriate design and arrangement of the protective conductor (see 7.4.3.1.1. last paragraph)	NO	Verification of the short-circuit withstand strength of the protective circuit by test or appropriate design and arrangement of the protective conductor (see 7.4.3.1.1. last paragraph)	NO

No	Characteristics to be checked	Type Tested Assembly (TTA) Tenderer to confirm compliance with the following type tests		Partially Type Tested Assembly (PTTA) Tenderer to confirm compliance by type test, calculation or visual inspections		Specially Type Tested Assembly (PTTA) Tenderer to confirm compliance by type test, calculation or visual inspections	
5	Clearances and creepage distances	Verification of clearances and creepage distances	YES	Verification of clearances and creepage distances	YES	Verification of clearances and creepage distances	YES
			NO		NO		NO
6	Mechanical Operation	Verification of mechanical operation	YES	Verification of mechanical operation	YES	Verification of mechanical operation	YES
			NO		NO		NO
7	Degree of protection	Verification of the degree of protection	YES	Verification of the degree of protection	YES	Verification of the degree of protection	YES
			NO		NO		NO

Tenderers are to list the fault free zones, cubicles, switching devices and associated control, measuring, signalling, protective, regulating equipment which are excluded from the above tests as they are considered unlikely to influence the performance.

	Equipment
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

For partially and specially type tested assemblies as a minimum, test 3 is to be verified by type testing, tests 1, 4 and 5 by calculation and tests 2, 6 and 7 by visual inspection (calculations and visual inspection to be signed off by a professionally registered electrical engineer employed by the manufacturer).

22. Cabling and Busbars

22.1 Standards

Where applicable, equipment shall comply with the latest edition and amendments of;

SANS 97 – Electric Cables (Impregnated paper insulated metal-sheathed)
SANS 1507 - Electric cables with extruded solid dielectric insulation for fixed installations
SANS 1339 – Electric Cables (XLPE)
BS1858 – Bitumin based filling compound
SANS 808 Glands for use on flameproof enclosures

22.2 Equipment

22.2.1 Busbars

Busbars are to consist of copper conductors. Phase conductors are to be fully rated for the current rating as shown (1.6A/mm^2) with a maximum rise of 15°C (on the copper) above an ambient room temperature of 40°C. The neutral bar is to be 100% of the rating of one of the phase conductors and made of copper. No internal earth conductor is required.

Conductors to be manufactured form 99% pure electrolytic copper.

The spacing of the bars is not to exceed 10 mm between the phase conductors and phase to neutral, except at the termination and joints. (Supplier to advise spacing at the joints at time of tender.)

The busbar is to be rated at IP54 over the complete length of busbar including joints.

Joint covers are to be manufactured with a fixing arrangement to allow easy and safe installation and removal, (cable ties are not acceptable). Joint cover material shall allow infra red testing of the joints without removing the cover.

Transformer and Main LV board panel flanged end feed units are to be suitably arranged to terminate on to transformer bushings via flexibles. Flexibles to be supplied with the busbar flanged end unit.

The busbar (including covers) shall be painted hammertoe grey Plascon CEP 5010.

Each section of busbar is to be tested at 2 kV for 1 minute at the factory and on site prior to installation on site. On completion of the busbar installation the busbar is to be retested at 2 kV for 1 minute.

All the above tests are to be recorded on a single test sheet per busbar run and submitted to the Engineer prior to energising.

Copies of the above test to be included in the as built manuals.

22.2.2 PILCSTA and PILCSWA Cables

Paper-insulated cables shall be manufactured in accordance with SANS 97.

Cable-end boxes shall comply with BS 542 and the filling compound to BS 1858.

The ends shall be terminated in cable-end boxes filled with bituminous cold filling or resin oil semi-fluid compound or heat-shrinkable terminations in accordance with the specification, and to the manufacturer's recommendation.

Before terminating or joining PILCSTA and PILCSWA cables, a test to establish the presence of moisture must be carried out. The test procedure must be forwarded to the Engineer for approval.

The armouring shall be bonded to the main earth bar of the switchgear or transformer, but the bond shall be easily removable for testing purposes.

All cut cable-ends, which will be exposed to the atmosphere for more than two hours shall be sealed and wiped to prevent penetration of moisture.

22.2.3 PVC-Insulated Cables

PVC-insulated cables shall be manufactured in accordance with SANS 1507.

PVC cable glands shall be made of a barrel carrying a cone bush screwed into one end and a nickel-plated brass nipple and galvanised steel lock-nut on the other end.

Flameproof glands shall comply with SANS 808 Groups 1, 2 (a) and 2 (b).

All cable ends shall be terminated with approved glands ensuring a watertight connection between the sheath, gland and equipment. In cases where copper ECC earth conductors are jointed to the armouring, special glands adhering to SANS 1507 shall be used for ECC cables.

The glands to be used shall be constructed so that the armouring of the cable is clamped between two bevelled cores with a screw-clamp, with the cable gland screwed to the gland plate or equipment and fixed with a locknut.

A neoprene or PVC shroud of the correct size shall be used to seal the gland and sheath watertight.

Cable end shall be supplied with the necessary earth connection.

A supporting channel or other approved means of support shall be provided to remove mechanical stress from the cable glands.

22.2.4 XLPE Cables

XLPE isolated cables shall be manufactured in accordance with SANS 1339 Table A.

Cable ends shall be terminated strictly in accordance with manufacturer's specifications. The termination shall withstand the same test voltage as the rest of the cable.

Termination for XLPE cables must have a satisfactory stress relief in order to keep the partial discharges extinguished.

Outdoor termination must be able to withstand air pollution and bad weather without any signs of surface current tracking.

Taped or prefabrication terminations may be used, in accordance with the manufacturer's recommendation.

22.3 Cable Installation

The storage, transportation, handling and laying of cables shall be according to first-class practice, and the Contractor shall have adequate and suitable equipment and labour to ensure that no damage is done to the cables during such operations.

All possible care shall be exercised in off-loading cables on site. Any drums which show signs of damage or mishandling, shall not be used and must be replaced with fresh stocks.

Cable drums remain the property of the Contractor and shall be removed from site and disposed of by him.

The Contractor is wholly responsible for making his own arrangements regarding the transportation to and from site, and the storage on site, of material and equipment; and the loss of or damage thereto, during transportation or storage on site, of material and equipment.

Tenderers shall satisfy the Engineer that they are competent to install/lay the cables specified, and must have had previous experience of cable laying and jointing of the sizes and types of cable indicated.

Where cables have to be drawn around corners, skid plates shall be used for this purpose, and these plates shall be well lubricated. The skid plates shall be securely fixed between rollers and shall be constantly examined during cable-laying operations.

Cables shall be visually inspected for damage during and after laying. Any damage shall be reported immediately to the Engineer, who will advise as to what action is to be taken.

The intention to carry out all cable-laying operations must be given to the Engineer, in advance, to allow inspection of the works.

Cable pulling and laying shall preferably be done manually wherever possible. Mechanical means, such as winches and the like, may only be used subject to the approval of the Engineer. No cable shall be subjected to a tension exceeding that stipulated by the cable manufacturer.

The Contractor shall maintain an approved means of communication between operators at the pulling end and the drum end of the cables, during laying operations.

L.V. cables (except where more than one run in a pipe) shall be spaced at least 150 mm apart. Two pilot cables can be run next to each other but must be
600 mm from the nearest 11 kV cable. Cables may not be buried or laid on top of each other.

Cable pipes must maintain or exceed the specified cable spacings. Where additional pipes or cable protection materials are required to be laid, the Engineer shall be advised timeously of the location and quantity of such materials required. The Contractor shall be responsible for the laying and jointing of these pipes, at a rate agreed before work commences.

All cables are to be labelled at each end and at every change in direction or position within a group of cables. Cables are to be labeled at both sides of horizontal or vertical penetrations through structure or building fabric.

Whenever cables enter building, or are exposed for any reason, the exposed portion shall be suitably protected by means of concrete slabs or suitable pipes or ducts, which shall be galvanised if of steel construction.

22.4 Testing and Commissioning

22.4.1 400V Cables

Low tension cables shall be tested to earth and between phases, with a 500 Volt “Megger” test set.

22.4.2 11000V Cables

11 kV cabling shall be as follows :

	500 V Megger between phases	500 V Megger between phases and SWA/copper tape	Pressure Test sheath to 4 kV DC between armouring and mass of earth for 1 minute	Pressure Test Phase to phase at 12 kV DC for 10 minutes
Cable drum arrival on site	X	X	-	-
After cable installed and before ends prepared	X	X	X	-
After ends are prepared, before bolting to equipment	X	X	-	X

On completion of the test on any cable, the Contractor shall, without delay, submit 3 (three) copies of Certified Test Reports to the Engineer.

The costs of all the tests mentioned above shall be borne by the Contractor as part of the tendered price.

The Engineer reserves the right to carry out any further tests deemed necessary, using the Contractor's instruments and equipment.

23. Cable Trays and Ladders

23.1 General

Cable trays and ladders shall comply with SANS 763 with respect to finishes.

The Contractor shall supply and install all cable trays and/or ladders as specified or as required including the necessary supports, clamps, hangers, fixing materials, bends, angles, junctions, reducers, T-pieces, etc. He shall further liaise with the Main Contractor for the provision of holes and access through the structure and finishes.

23.2 Supports

Trays shall be supported at the following ***maximum intervals***:

1.6mm Thick metal trayswith 12mm return	1000mm
Metal trays with folded overreturn and 50mm upstand	1220mm
2.4mm Thick metal trays and 75mm return	1500mm
Metal cable ladders other than those mentioned below	1500mm
3.0mm Thick PVC trays with 40mm return	1000mm
4.0mm Thick PVC trays with 60mm return	1500mm

In addition, trays and ladders shall be supported at each bend, offset and T-junction. The above spacing of supports is applicable to both vertical and horizontal installation of trays and ladders.

23.3 Joints

Joints shall be smooth without projections or rough edges that may damage the cables. The Contractor will be required to cover joints with rubber cement or other non-hardening rubberised or plastic compound if in the opinion of the Engineer joints may damage cables. Joints shall as far as possible be arranged to occur at supports. Where joints do not coincide with supports, joint shall, in the case of trays with single returns, be made by means of wrap-around pieces of the same thickness of the tray and at least 450mm long. The two cable tray ends shall butt tightly at the centre of the splice and the splice shall be bolted to each cable tray by means of at least eight round head bolts, nuts and washers. Splices shall have the same finish as the rest of the tray. Where joints which do not coincide with supports occur in trays with folded over returns, tight fitting metal guide pieces, at least 450mm long, shall be inserted in the folded return to provide the necessary support to the two cable tray ends. Splices as described above shall be provided at joints, which do coincide with supports if the loaded tray sags adjacent to the joint due to the interruption of the bending moment in the tray.

23.4 Fixing

Trays and cable ladders shall be bolted to supports by at least two round head bolts per support. Bolts shall be securely tightened against the tray surface to avoid projections, which might damage cables during installation.

23.5 Fixing to the Structure

The support for cable trays and ladders shall in all cases be securely fixed to the structure by means of heavy duty, expansion-type anchor bolts. Cantilevered trays shall be supported at two points with a minimum of two expansion bolts per support. It is the responsibility of the Contractor to ensure that adequate fixing is provided since cable trays and ladders that work loose shall be rectified at his expense. The fixing shall take into account site conditions that prevail during installation.

23.6 Earthing

Metal trays and ladders shall be bonded to the earth bar of the switchboard to which the cables are connected with a Cu PVC cable. Bare copper stranded conductors or copper tape shall be bolted to the tray or ladder to ensure electrical continuity. These shall be installed on the outside of the tray to ensure they are visible and are not damaged by cable installation.

23.7 Expansion Joints

Where cable trays/ladders have to cross expansion joints, the trays/ladders must form a gap of at least 25mm between the two sections. Cables installed across expansion joints, must have enough slack to accommodate the expansion of the building.

24. Trenching

Tenderers are to note that:

Hard rock:

shall mean granite, quartzitic sandstone, slate and rock of a similar or greater hardness, solid shale and boulders over 0,03m³ in volume.

Soft rock:
shall mean rock that can be loosened by hand-pick and includes hard shale, compact ouklip and boulders from 75mm in diameter up to 0,03m³ in volume.

Earth

shall mean ground that can be removed by pick and hand shovel and includes loose gravel, clay, made-up ground, loose or soft shale, loose ouklip and boulders less than 75mm in diameter.

25. Conduit and Wiring Channels

Unless otherwise specified, all conduit is to be concealed by casting/building into walls and slabs, or by running in ceiling spaces and within purlins.

Conduit runs to wall luminaire outlets shall, in all instances, be from above the outlet and not below via floor slabs. No conduit is permitted in ground slabs, unless otherwise indicated on the drawings, or required by building construction techniques and sequences. Luminaire conduit shall be looped from outlet to outlet, and no additional drawbox positions will be permitted.

No more than two right-angled bends between draw boxes is permitted.

All 150 x 50, 150 x 150, or larger, terminal conduit boxes shall be of galvanised steel type. The corresponding PVC type will not be accepted. PVC round conduit boxes that have covers fixed by screwing directly into the PVC box, are unacceptable.

In coastal areas (within 70 kms of the coastline) all galvanised sheet steel outlet boxes are to be given two coats of Red Lead or Glyptal Primer, before installation.

Conduit shall only be run parallel or at right angles to outside walls when run in ceiling spaces, unless otherwise indicated on drawings.

Exposed metal conduit threads are to be protected against corrosion.

No running joints are allowed unless agreed by the Engineer, in writing.

Black enamelled steel conduit may not be used in coastal areas. All steel conduit systems must be electrically continuous. PVC conduit systems are to be provided with an earth wire for each circuit.

All draw trays shall be sheet steel galvanised and painted as above, or as specified.

Conduits across expansion joints shall be arranged in such a manner that each side of the joint is free to move relative to the other, without damage to conduit or wiring.

Unless otherwise indicated, only one circuit is to be installed in each conduit. This does not apply to conduits rising from distribution draw trays. In this case the Contractor is to de-rate conductors by 50% (fifty per centum) and ensure that conduit trunking capacity is adequate to provide 50% (fifty per centum) (maximum) occupancy.

Final positions of all outlets are to be verified on site with the Structural Engineer's detailed drawings.

In general, the following heights above finished floor level, to underside of box are to be observed unless otherwise indicated on the drawings:

Wall switches	Door handle height
Wall outlets for luminaries	2100 mm
Wall mounted socket outlets	500 mm
Wall mounted socket outlets in kitchen and over work tops	150mm above counter
Bells, buzzers and fire alarm bells	2400 mm
Fire alarms	1600 mm
Telephone outlets	500 mm
Clock outlets	2400 mm

Where the Engineer has any reason to suspect that wiring has been damaged during drawing into conduit, the Contractor will be requested to withdraw the wiring for inspection. For pricing purposes sub-contractors should allow for the withdrawing and reinstatement of five circuits, overall.

The Contractor should, therefore make due allowance for this.

The conduit routes shown on the drawings are schematic, and the Contractor must ensure that the manner of installation and routing of all conduit is carried out in accordance with the Regulations and good engineering practice, and takes cognizance of the relevant architectural/building restraints.

The capacity of conduits will be checked on site. Where the recommended capacity is exceeded, the Contractor will be required to re-wire the circuits concerned.

All accessories such as boxes for socket outlets, switches, lights, etc., shall be accurately positioned. It is the responsibility of the Contractor to ensure that all accessories are installed level, square, and at the correct height.

It shall be the responsibility of the Contractor to determine the correct final floor, ceiling and roof levels in conjunction with the Principal Contractor. Draw boxes shall be installed as inconspicuously as possible and shall not be installed in positions where they will be inaccessible after completion of the installation. Positions of all draw boxes shall be indicated on the "AS BUILT" drawings.

Galvanised steel draw wires shall be installed in all unwired conduits, e.g., conduits for future extensions, telephone installations and other services.

A maximum of two 90° bends or the equivalent displacement will be allowed between outlets and/or boxes.

Care shall be taken to prevent debris or moisture entering conduits during and after installation. Conduit ends shall be sealed by means of a solid plug, which shall be screwed to the conduit end. Conduits shall be cleaned and swabbed to remove oil, moisture or other debris that may be present before conductors are installed. Swabs shall not be attached to the conductors.

25.1 Termination of Conduits

a) Switchboards, Power skirting, etc.

Conduits shall be terminated by means of a brass female bush and two lock nuts in distribution boards and power skirting, etc. The conduit end shall only project far enough through the hole to accommodate the bush and lock nut.

b) Draw Boxes

A female bush and two lock nuts shall be used to terminate conduits at draw boxes should there be sufficient room in the box. Where there is insufficient room, a coupling and a brass male bush may be used with sufficient allowance for the reduction of the internal diameter by the male bush.

25.2 Screws, Bolts and Nuts

Steel locknuts of thick gauge steel with milled sides shall be used in all cases. Cadmium-plated bolts and nuts shall be used, except where the installation is exposed to the weather, in which case brass bolts and nuts shall be used. Screws shall be installed in all tapped holes in fittings and accessories to prevent damage to the screw thread by concrete or plaster. The screws shall be screwed down completely to prevent damage to the thread on the screw.

25.3 Installation in Concrete

a) Timeous Installation

In order to prevent delay to building operations, the Contractor shall ensure that all conduits and accessories to be cast into concrete are placed in position in good time. Once the installation has been completed, the Contractor shall advise the Engineer in order that he may inspect the installation prior to concrete being cast. The Contractor or his representative shall be in attendance when the concrete is cast.

b) Draw Boxes and Joints

Draw boxes, expansion joints and round ceiling boxes shall be installed where required, and shall be neatly finished to match the finished slab and wall surfaces. Ceiling draw boxes shall be of the deep type. In hollow tile slabs, rear entry draw boxes shall be used. In columns where flush mounted draw boxes are installed, the conduits shall be offset from the surface of the column immediately after leaving the draw box.

Draw boxes shall be installed at maximum intervals of 15m in straight runs. Where these boxes will be visible on the bottom of ceiling slabs, the boxes shall be positioned so that they will be hidden by light fittings, etc.

Couplings are to be taped up with adhesive rubber tape to prevent the ingress of concrete slurry.

c) Cover Plates

Draw boxes and/or inspection boxes shall where possible; be grouped together under a common approved plate. The cover plate shall be secured by means of screws.

d) Fixing to the Shuttering

All conduits, draw boxes, etc., shall be securely fixed to the shuttering to prevent displacement when concrete is cast. Draw boxes and outlet boxes shall preferably be secured by means of a bolt and nut installed from the back of the box, through the shuttering. Wire will not be accepted for securing boxes to the shuttering where off-shutter finishes are required. Where fibre-glass shuttering is used, the conduits and boxes shall be fixed to the reinforcing steel only and no holes shall be drilled or made in shuttering.

All draw boxes and outlet boxes shall be plugged with wet paper before they are secured to the shuttering.

e) Expansion Joints

Conduits shall not be installed across expansion joints if avoidable.

f) Screed

Where conduits are installed in screed, the top of the conduit shall be at least 20mm below the surface of the screed. A minimum distance of twice the outside diameter of the conduit shall be left free between adjoining conduits. Conduits shall be secured to the concrete slab at intervals not exceeding 2.0m.

g) Inspection

After removal of shuttering, all conduits shall be checked to ensure that they are not blocked. Errors that occur during the installation of the conduits, or any lost draw boxes, or blocked conduits shall be immediately reported to the Engineer in order that an alternative route may be planned and approved before any additional concrete is cast.

25.4 Surface Installation

a) Appearance

All conduits shall be installed horizontally or vertically as determined by the route. Where conduits are to be installed directly alongside doorframes, beams, etc., that are not true, the conduits shall be installed parallel to these.

b) Saddles

Conduits shall be firmly secured by means of equidistant spaced saddles. Conduits shall be secured within 150mm before and after each 90□ bend. Saddles shall be fixed by means of screws and plugs and not by means of nails.

c) Joints

Joints will only be allowed in surface conduit lengths exceeding 3500mm.

d) Accessories

Inspection bends or tee pieces shall not be used. Non-inspection type bends may be used in the case of 32mm or 50mm diameter conduits.

All draw boxes supporting light fittings or other equipment shall be fixed independently of the conduit installation.

e) Offsets

Where an offset is required at conduit terminations or cross-overs, the conduit shall be saddled at the offset.

f) Cross-overs

Conduit routes shall be carefully planned to avoid cross-overs. Where a cross-over is unavoidable, one conduit only shall be offset to cross the other. Alternatively, cross-overs shall be installed in purpose-made boxes.

g) Parallel Conduit Runs

Parallel conduit runs shall be equidistantly spaced and saddles shall be installed in line. Alternatively, a special clamp can be used to secure all conduits together.

h) Painting of Conduits

All surface mounted conduits and accessories shall be painted with high quality enamel paint or as otherwise specified. The colour shall comply with the colour code specified for the installation, or where no code has been specified, shall match the colour of the surrounding finishes.

25.5 Future Extensions

a) Open Roof Spaces

Conduits for future switch and socket outlets in roof spaces with more than 900mm free space shall terminate 40mm above the tie beams. The conduit ends shall be threaded and provided with a coupling and brass plug.

b) Concrete Slabs

Conduit ends shall protrude 150mm from the concrete to facilitate the installation of future extensions. All such conduits shall be connected to a draw box, which is cast into the concrete within 2m of the end of the concrete. Conduit ends shall be threaded and provided with a coupling and brass plug. In cases where holes cannot be drilled through the shuttering to accommodate the conduit end, a deep draw box with rear entry may be placed around the conduit end.

c) Cover Plates

All boxes for future switch and socket outlets shall be covered by blank cover plates. All boxes for future light fittings shall be covered with round oversized cover plates.

25.6 Expansion Joints

Where conduits cross expansion joints in the structure, approved type draw boxes, which provide a flexible connection in the conduit installation, shall be provided.

The draw box shall be installed adjacent to the expansion joint of the structure and a conduit sleeve one size larger than that specified for the circuit, shall be provided on the side of the draw box nearest the joint. The one end of the sleeve shall terminate at the edge of the joint and the other shall be secured to the draw box, by means of locknuts and a standard bushed adaptor.

The circuit conduit passing through the sleeve shall be terminated 40mm inside the draw box and in the case of metallic conduit; the conduit end shall be fitted with a brass bush. The gap between the sleeve and the conduit at the joint shall be sealed to prevent ingress of wet cement. In the case of metallic conduit, an earth clip shall be fitted to the conduit projection inside the draw box and the conduit bonded to the box by means of 2.5mm² bare copper earth wire and a brass bolt and nut.

In addition to an earth wire, which may be specified for the circuit, a 2.5mm² bare copper wire shall be provided between the first conduit box on either side of the joint in the case of metallic conduit. The conduit boxes shall be drilled and tapped, and the earth wire shall be bonded to the boxes by means of lugs and brass screws.

Draw boxes and the expansion joint shall be provided with a suitable steel cover plate fixed to the box by means of screws. The cover plates shall be installed before the ceilings are painted.

Where a number of conduits are installed in parallel they shall cross the expansion joints of the structure via a single draw box. A number of draw boxes adjacent to each other will not be allowed.

25.7 Chases and Builder's Work

Electrical materials required to be built-in shall be supplied and fixed in position by the Contractor as required by the programme of the Principal Contractor. The Contractor shall ensure that these materials are installed in the correct positions.

On contracts on which there is no builder, the Electrical Contractor shall cover conduits installed in chases by means of a 4:1 mixture of coarse sand and cement, finished 6mm

below the face of the plaster and roughened. In all cases, chases shall be deep enough to ensure that the conduits are at least 20mm below the finished plaster surface.

Where the Contractor is responsible for the cutting of chases, building-in of conduits or other equipment, he will be held responsible for all damage as a result of this work and will be required to make good. Chases shall be carried out by means of a cutting machine.

Under no circumstances shall face brick walls or finished surfaces be chased or cut without the written permission of the Engineer. Where it is necessary to cut or drill holes in the concrete structure, the prior permission of the Structural Engineer shall be obtained.

25.8 Wiring Channels

The channels shall be either hot dip galvanised or electro-galvanised, shall be coated with cold galvanising at all joints, sections that have been cut and at places where the galvanising has been damaged. Powder coated ducts shall be touched up at joints, cuts and damaged portions, using paint recommended by the manufacturer of the channels.

a) Cover Plates

Channels up to 125mm wide shall have snap-in cover plates of metal or PVC, whilst channels wider than 125mm shall have metal cover plates fixed in position by screws.

The finish of steel cover plates shall be the same as that of the channels.

b) Accessories

All accessories, i.e., hangers, brackets, etc., shall be purpose-made and in general have the same finish as the channels.

c) Capacities of Channels

Trunking is defined as a channel having one or more sides removable for access to wiring, whilst ducting has no removable sides.

In the case of trunking, the overall cross-sectional areas of all the conductors, including insulation, shall not exceed 45% of the internal cross-sectional area of the trunking whilst in the case of ducting, this figure shall be 40%.

Where trunking or ducting is run in a distribution board, it shall be filled to not more than 30% unless it is ventilated, in which case, the former figures shall apply.

Common wire ways will be permitted only in the case of conductors carrying relatively low currents, namely lighting and single phase socket outlet circuits. In such cases, the maximum number of wires per conduit shall be in accordance with SANS 10142.

d) Fixing of Channels

The Contractor shall supply and install all hangers, supports or fixings for the channels. Channels up to 75 x 75mm shall be supported at maximum intervals of 600mm and larger channels at maximum intervals of 1m. Channel runs shall be carefully planned to avoid clashes with other services and to ensure that all covers can be removed after completion of the entire installation. Purpose-made clamps, hangers etc., shall be used as required. Where it is not possible to support the channels at the specified intervals, they shall be supported in a sound manner to the satisfaction of the Engineer.

e) Installation in Concrete

Channels shall be filled with polystyrene or other suitable fillers to prevent ingress of cement and shall be securely fixed in position to the shuttering.

f) Joints

Adjoining lengths shall be aligned and securely jointed by means of fishplates fixed by mushroom bolts, washers and nuts or connection pieces that are pop-riveted to both adjoining sections. Adjoining sections shall butt tightly. Covers shall fit tightly across the joint.

Where channels cross expansion joints in the concrete, suitable expansion joints shall be provided in the channels by means of fishplates pop-riveted or screwed to the channel on one side of the expansion joint and floating freely in the channel on the other side of the expansion joint.

g) Support for Conductors

All conductors in inverted cable channels shall be retained by means of metal clips or metal spacer bars at not less than 1m centres. Clamps shall be provided on suitable draw boxes for this purpose.

h) Internal Finishes

Burrs and sharp edges shall be removed and the inside edges of all joints shall be lined with rubber cement or other suitable rubberised or plastic compound to prevent laceration of the conductor insulation.

All holes through which conductors pass shall be fitted with grommets.

i) Vermin Proofing

All wire ways shall be vermin proof after installation. Holes shall be covered by means of screwed metal plugs or by means of metal strips that are bolted or pop-riveted to the channel.

26. Wiring Installation

26.1 Type of Conductors

All wiring shall be carried out with PVC insulated, stranded copper conductors and bare stranded copper earth wires, complying with SANS 10150.

Conductors shall be installed in conduit, trunking or ducting. Under no circumstances will open wiring be acceptable.

Where surface wiring cannot be avoided, aluminium sheathed cable may be used instead of surface mounted conduit, but prior permission from the Engineer shall be obtained.

Conductors connected to different distribution boards shall not be installed in a common wire way.

26.2 Looping

All wiring shall be carried out by means of the loop-in system. Jointing of conductors shall only be carried out in accessible boxes or in conduit runs. Conductor jointing shall be carried out by means of ferrules insulated with PVC tape.

26.3 Grouping of Circuits

Where conductors of more than one circuit are installed in wire ways, the conductors of each circuit shall be taped together at intervals of one metre with PVC tape. A common unbroken earth conductor may be installed into the wire ways, and subsidiary earth wires to the various outlets, shall be connected to this earth wire by means of crimped connections.

26.4 Different Phases

With the exception of 3-phase outlets, circuits of different phases shall not be present at switch or socket outlet boxes.

26.5 Vertical Wireways

Conductors installed in vertical wireways shall be secured at intervals not exceeding 5m in order to support the mass of the conductors. Suitable clamps shall be provided for this purpose.

26.6 Connections

When more than one conductor enters a terminal, the strands shall be securely twisted together. Under no circumstances shall strands be cut off.

26.7 Earthing Conductors

When earth continuity conductors are looped between outlets, the looped conductor ends shall be twisted together and then soldered or ferruled in order to ensure that earth continuity is maintained when the conductor is removed from a terminal.

When a single earth conductor is used for a group of current carrying conductors as in power skirting trunking or ducting, the size of the earth conductor shall be to the approval of the Local Supply Authority.

26.8 Single Pole Switches

Single pole switches shall be connected so as to break the phase conductor, and not the neutral conductor.

26.9 Wiring in Partitions

Where wiring is installed in demountable partitions, the metal supports for the partitions may be utilised for carrying wiring subject to:

a) The conductors not being exposed,

b) the metal supports being properly earthed,

c) a separate bare earth continuity conductor being drawn in together with the current carrying conductors, with this earth continuity conductor being connected to the metal parts of the switches and socket outlets, and

d) the conductors being installed in non-flammable sections of the partitions.

Conductors enclosed in copper braiding may be installed in demountable partitions.

The braiding may be used as the earth continuity conductor. This wiring shall be jointed to the conduit or cable installation by means of jointing the conductors and earth continuity conductor in a suitable draw box with ferrules or screwed terminal blocks. This draw box shall be situated immediately above the partition.

26.10 Colours

The colours of conductor insulation for sub-circuits shall, as far as possible, correspond with the colour of the supply phase. The colours of conductors for the wiring of two-way and intermediate switches shall differ from those of phase conductors.

Not more than two wires are to be terminated at any one terminal.

Before terminating, the strands of the conductor are to be tightly twisted to ensure a good and lasting terminal contact. Untwisted wire terminations will be rejected.

Insulation of wiring or cable conductors that have been nicked or cut during preparation of the end will be rejected if these cannot be adequately reinstated by oversleeving.

Insulation must not be pared back excessively at the terminal. Maximum excess of 3 mm is permitted.

Wiring connections to luminaires should either be looped in and out without being cut in half or a scotch clip type T off connection used to avoid intermittent and difficult to locate open circuits occurring.

26.11 Within Distribution Boards

All boards are to be left in a completely clean and dust free condition.

Incoming wiring must be neatly run and located clear of equipment.

During installation, paintwork is to be protected at all times.

Unless otherwise agreed, not more than one live or incoming supply is permitted per board and all incoming live wiring is to be simultaneously isolated by a single action isolating device.

Live terminals in boards are to be shrouded.

All terminals and busbars are to be checked for tightness.

Circuit cards are to indicate circuit numbers as on the layout drawings, phasing, type of circuit and circuit identity i.e. "s.s.o's for fridges 11 to 15" etc.

Final circuit labelling is to be given to the board manufacturer by the contractor and shall reflect layout drawing circuit number and phasing.

All metal in or on boards is to be effectively earthed.

Any holes required on gland plates or boards are to be neatly punched and the bare metal treated to prevent rust.

26.12 Wiring Terminals

a) Terminal bodies and screws shall be of non-corrosive metal, enclosed in fire resistant, moulded plastic insulating bodies. Terminal bodies or screws shall not project beyond the insulating material and shall afford suitable protection against accidental contact by personnel and against short circuits and tracking.

b) The construction of the terminal block and mounting rail shall be such as to ensure a firm and positive location of the terminal blocks. It shall be possible to add additional terminal blocks within the terminal sequence without having to disconnect or dismantle the terminal strip. The terminal blocks shall be held in position by means of standard end clamps.

c) It shall be possible to intermix terminals of various sizes, i.e. for different sizes of conductors, whilst utilising the same mounting rail. Where smaller terminal blocks occur adjacent to larger terminal blocks, suitable shielding barriers shall be inserted to cover the terminals that might otherwise be exposed.

d) The terminal bodies and clamping screws shall be so constructed as to ensure that conductors are not nicked or severed when the clamping screws are tightened. Screws shall not come in direct contact with the conductors.

e) Terminals shall be sized and rated to match the conductors that are connected to them.

f) Each terminal block shall have provision for clip-in numbering or labelling strips to be installed, together with protective, clear caps over the sheets.

27. Luminaires

27.1 General

The mounting positions of light fittings shall be verified on site. All fittings shall be placed symmetrically with respect to ceiling panels, battens, beams, columns or other architectural features of the space unless otherwise shown.

The layout as shown in the document shall generally be adhered to, but any discrepancies or clashes with structural or other features must be referred to the Engineer before commencing with the installation. Should the Contractor neglect to refer such discrepancies to the Engineer, costs incurred as a result of subsequent alterations to suit the building or structural features will be for the Contractor's account.

27.2 Cover Plates

Cover plates shall be fitted over all draw boxes and outlets intended for fittings that are not covered by the fitting canopy, lamp holder, ceiling rose or similar accessories.

27.3 Fixing to Draw Boxes

Where an outlet box or draw box provides the necessary support for light fittings, all fittings with the exception of fluorescent fittings mounted against the ceiling shall be fixed directly to the box. Fittings with a mass in excess of 10kg shall however be suspended independently of the outlet box.

27.4 Hangers and Supports

Where provision has not been made for the fixing of fittings, the Contractor shall supply the necessary supports, hangers, conduit extensions, angle brackets or any other fixing method approved by the Engineer.

27.5 Suspended Luminaires

The necessary hangers shall be provided where fittings, which are of the non-suspension type, have to be fixed below roof slabs. The use of 20mm conduits fixed to the roof slab is preferred. Provision shall be made for adjustments to enable the levelling of fittings.

Suspended conduit shall be fixed to the ceiling by means of screwed dome lids, bolts and nuts. Ball-and-joint type dome lids shall be used where conduit lengths exceed 600mm. Wiring shall be installed in the conduit hangers.

27.6 Suspended Wiring Channels

Light fittings (especially fluorescent fittings) may also be suspended from ceilings by means of suspended metal channels. The metal channel may be supported by conduits or threaded rods. Should metal rods be utilised, these shall be screwed to anchor bolts fixed in the roof slab. Wiring shall either be installed in conduits fixed to the metal channel or in the metal channels, covered with a suitable cover plate. Purpose-made clamps shall be used to fix the fittings to the wiring channel.

27.7 Fittings Fixed to False Ceilings

In all cases where light fittings are fixed to false ceilings, the Contractor shall ensure that the ceiling is capable of carrying the weight of the fittings before commencing installation. Should any doubt exist in this regard, the matter shall be referred to the Engineer.

When fluorescent fittings are fitted to false ceilings they should be flush mounted with no visible gap if possible. Where the construction of the fitting causes a gap between the fitting and ceiling, the maximum gap allowable is 2mm. The fitting shall be fixed to the ceiling beams. In the case of tiled ceilings with exposed or concealed T-section supports,

the fittings shall be fixed to the metal supports by means of butterfly screws or bolts with nuts and washers. Self-tapping screws may not be used. Fittings shall be neatly fixed with regard to the ceiling layout.

27.8 Glassbowl Fittings

Unless specified to the contrary, glass bowl fittings shall be installed with the underside at least 2m above finished floor.

27.9 Fluorescent Fittings Fixed to Concrete Slabs

Fluorescent fittings to be installed directly against concrete slabs or walls shall be fixed to the outlet box and at two additional points.

Shot-fired fixings are not acceptable. If specified or where approved by the Engineer, fluorescent fittings may be fixed to metal channels installed against concrete slabs or walls. The metal channel fixing may, in this case, be shot-fired. Purpose-made clamps shall be used to fix fittings to wiring channels.

27.10 Continuous Rows of Light Fittings

In cases where fluorescent fittings are installed end to end in a continuous row only one connection outlet per circuit need be supplied.

All fittings shall be coupled to one another by means of nipples or brass bushes and locknuts to ensure that wiring is not exposed and that earth continuity is maintained. Fittings on the same circuit may be wired through the channel formed by the fitting bodies. In this case internal connections shall be made at terminal blocks. The wiring for any other circuits or outlets, even though these may be in the same row may not be installed through the fitting canopies. The Contractor shall ensure continuous rows are straight and parallel to the relevant building lines.

27.11 Recessed Light Fittings

In all false ceilings where wiring channels are used, recessed light fittings shall be connected to the main wiring channels by means of 5A sockets mounted on or adjacent to the channels and 0.5mm^2, 3 core flexible cable complete with 5A plug tops, not exceeding 3m in length.

27.12 Special Ceilings

In cases where special ceilings e.g., aluminium strips, decorative glass, metal leaves, etc., are to be installed, the Contractor and Manufacturer of the ceiling shall agree upon the method of fixing of light fittings in the ceiling.

27.13 Bulkhead Fittings

Surface mounted bulkhead fittings shall not be screwed directly to conduit ends. The conduit shall terminate in a round draw box at the top or rear of the fittings. The PVC insulated conductors shall terminate in a porcelain terminal strip in the draw box. Asbestos or silicon-rubber insulated conductors shall be installed from the terminal strip to the fitting lamp holder. Screw-type connectors are not acceptable (e.g., "SCREW IT").

27.14 Connections to Light Fittings

a) Connectors

Where connectors have to be provided to effect connections to the wiring of light fittings and other appliances, brass screw couplers shrouded in porcelain, neoprene or PVC or approved spring steel locking connectors insulated in unbreakable material shall be used. Other types of connectors are not acceptable (e.g., "SCREW IT").

b) Knock-outs

Where knockouts are used for the wiring of light fittings and other appliances, brass bushes or gripper glands shall be provided.

c) Type of Conductor

PVC insulated conductors, unless protected by an approved heat resistant sheathing, should not be used where the temperature of the insulation is likely to exceed 70º C. In fittings capable of housing incandescent lamps above 60W, the interconnecting wiring from the lamp holder to the circuit wiring shall consist of varnished cambric insulated roved and braided asbestos or heat resisting silicon compound insulated conductors. Refer also the provisions of SANS 10142, Clause 6.21.1 (f).

27.15 High Bay Fittings

The Contractor and luminaire manufacturer shall decide upon the method of fixing fittings in the ceiling, whether by suspending from the roof purlins or mounting on cross-beams. The Engineer shall approve the method before the fittings are fixed. Fittings must be fixed at least 1m above the maximum working height, e.g., above the maximum reach of cranes.

The lighting circuits shall be wired with 4mm² PVC insulated conductors in a 3-phase configuration and 2.5mm² bare copper earth conductors installed in "Unistruts".

High-bay fittings shall be suitable to accommodate 250W or 400W elliptical or tubular mercury vapour coated, high-pressure sodium or metal halide lamps and associated control gear as required.

All high-bay fittings shall be supplied with a safety chain.

27.16 Tubular Fluorescent Lamp Luminaires for Interior Applications

a) General

Light fittings, associated equipment and control gear shall be new and unused and shall be supplied complete with lamps, control gear, diffusers, mounting brackets etc., as applicable, and shall be delivered to site in a protective covering.

Tenders shall be accompanied by full descriptive information of the light fittings offered. Photometric data, i.e., polar curves and coefficients of utilization certified by the SABS shall be submitted with tenders for luminaires offered. Photometric data shall not be older than 2 years.

b) Technical Requirements

Tubular fluorescent lamp luminaires shall bear the SABS mark and comply fully with SANS 1119 and all amendments as well as the additional requirements of this specification. Components shall bear the SABS mark where applicable.

The reflector shall be firmly held in position with a latching device operating on one of the following principles:

i) Spring steel latches.

ii) Spring loaded latches and locating pins.

ii) Non-detachable plated metal or plastic screws, with or without locating pins.

Plastic used as a spring mechanism is not acceptable as a fixing device for reflectors.

All components including screws, bolts and nuts utilized in the construction of the luminaire for fixing its components shall be corrosion proof.

Industrial type luminaires shall be fitted with detachable side reflectors, manufactured of cold rolled steel, not less than 0.7mm thickness. The design of the reflectors shall be such to improve the downward light output ratio and decrease the upward light output ratio to a value of less than 2%.

c) Control Gear for Fluorescent Lamp Luminaires

Ballasts shall comply with SANS 890 and 891 and bear the SABS mark.

Ballasts shall further be suitable for the fitting to ensure that the thermal limits specified in SANS 890 and 891 are not exceeded.

d) Lamps

If no colour is specified in the Detail Specification, the light colour shall correspond to colour 2 (4300 °K) of SANS 1041.

e) Lamp Holders

Lamp holders shall preferably be of the spring loaded telescopic type, but ratchet types such as "ROTOLOK" or "TWISTLOCK" are acceptable. Where ratchet types are used a 1mm air path shall be allowed between the lamp cap and lamp holder and the lamp holder shall house a rotational inset to accommodate the lamp rotation.

All lamp holders provided shall be suitable to accommodate from 0.5mm² solid core wire and allow for 2.0mm lamp tolerance compensation.

f) Paint Finish

Sheet metal components of the luminaire shall be painted in accordance with SANS 1119. Baked enamel, electro statically applied powder coating or similar proven methods may be used.

Care shall be taken to ensure that all edges and corners are properly covered.

The finish shall be smooth, glossy and free from grit or any other surface imperfections.

Prior to painting, all metal parts shall be thoroughly cleaned of rust, mill scale, grease and foreign matter to a continuous metallic finish. Sand or shot blasting or acid pickling and washing shall be employed for this purpose.

The paint process shall conform SANS 1274 type 3.

28. Terminal Devices

28.1 General

This section covers the requirements for switches and sockets for installation under normal environmental conditions.

a) Switches shall comply with SANS 60669 as amended.

b) Sockets shall comply with SANS 164 as amended.

28.2 Escutcheon Plates

Where flush mounted switches or sockets are installed in special wall finishes e.g., wood or board panels, acoustic tiles or other cladding, etc., and where the wall finishes have to be cut to accommodate the switch, it may be necessary to fix an escutcheon plate to the wall to cover the cut-outs. The escutcheon plate shall fit closely around the switch boxes and shall be fixed independently of the switch boxes and cover plates. Bevelled cover plates that overlap the switch boxes shall be used. Cover plates shall be fixed to the switch boxes and shall fit firmly against the escutcheon plate.

28.3 Flush Cover Plates

a) Cover plates shall conform to SANS 60669 and SANS 1085 and shall bear the SABS mark.

b) Cover plates shall be finished in ivory coloured baked enamel, anodised aluminium or natural bronze unless otherwise specified.

c) Cover plates shall have bevelled edges which overlap the box in order to mask rough wall finishes.

d) Cover plates shall under no circumstances be cut unless specifically authorised by the Engineer.

Appearance

All boxes and cover plates shall be installed parallel to and in line with relevant horizontal and vertical planes unless specified to the contrary.

The sides of adjacent switches, sockets, push-buttons, etc., shall be parallel or perpendicular to each other and uniformly spaced.

All switches and sockets shall be of the same manufacture / product range, and shall be sampled for approval prior to order.

28.4 Light Switches

Wall and Surface Mounted Switches

a) All light switches shall be installed at door handle height unless specified to the contrary. Mounting heights given shall be measured from the finished floor level to the centre of the switch.

b) All switches shall be suitable for mounting in 100mm x 50mm x 50mm galvanised steel or stove enamelled boxes.

c) Unless otherwise specified, switches shall be of the tumbler operated microgap, 250V, 16A type and of silent operation.

d) Where more than one switch is required at any one position, approved multiple-gang units shall be used and installed in a common switch box.

Watertight Switches

a) Switches that are exposed to the weather or are installed in damp areas, shall be of the waterproof type.

b) Watertight switches shall be 16A, single pole, unless specified to the contrary, and suitable for surface mounting.

c) The switch mechanism may be on the front or side of the box but the ON/OFF positions shall be clearly marked.

Pull Switches

a) Pull switches shall be rated 10A as required and shall be suitable for ceiling mounting on a round conduit box. They shall contain heavy brass contacts and a strong quick acting mechanism, and be suitable for operation on 250V, 50Hz systems.

b) Each switch shall be complete with a 1.25m length of nylon cord.

Partition Switches

a) Light switches installed in mullions shall be purpose-made.

b) Switches installed in the metal supports do not require switch boxes.

c) Switches may not be flush mounted in partition walls without switch boxes.

28.5 Socket Outlets

a) Switched sockets shall be suitable for use with 400/230V, 50Hz systems and switches and sockets shall be rated not more than 16A, 250V or 63A, 400V unless specified to the contrary.

b) Miniature circuit breakers of the correct rating may be used in lieu of a switch with single phase sockets where specified. Miniature circuit breakers shall be contained under the same cover plate and shall conform to SANS 156.

Flush Socket Outlets

Flush Socket outlets shall be of the Legrand, Crabtree, Clipsal, or approved equal type.

Flush sockets shall consist of a 16A switch and 3-pin plug receptacle with shuttered live and neutral sockets and an earth socket operating the shutters conforming to SANS 164-1, and a 16A switch and 3-pin plug receptacle with shuttered live and neutral sockets and an earth socket conforming to SANS 164-2, . Unless otherwise specified the unit shall be suitable for mounting in a standard 100 x 100 x 50mm box, and shall consist of white inserts in white cover plates:

Mounting Heights

Mounting heights given shall be measured from the finished floor level to the centre of the socket. Unless otherwise specified socket outlets shall be installed at the following heights above finished floor levels:

Flush mounted, in general	300mm

Surface mounted, in general	1400mm
Kitchens, laundries, shops	1100mm
Factories, workshops, garages	1400mm

Walls

Where the lower portions of brick walls consist of face bricks and the upper portion of the wall is plastered, the outlets shall be installed in the plastered portion of the wall. If however the plastered portion of the wall commences 650mm or more above floor level, the outlets shall be installed in the face bricks. Where a wall has different surface finishes, the outlets shall be installed on one of the walls finishes only and not in the joints between the different wall finishes. All outlets shall be installed at least 150mm away from door frames.

Surface Mounted Socket Outlets

Sockets for surface mounting shall consist of units equal to the flush mounted units, but contained in a purpose-made pressed steel box, conforming to SANS 1065 and SANS 1085 where applicable.

Dedicated Socket Outlets

Dedicated socket outlets shall be of the Legrand, Crabtree, Clipsal, or approved equal type.

Dedicated sockets shall consist of a 16A switch and 3-pin plug receptacle with shuttered live and neutral sockets and an earth socket operating the shutters conforming to SANS 164-4. Unless otherwise specified the unit shall be suitable for mounting in a standard 100 x 100 x 50mm box, and shall consist of red inserts in red cover plates:

Dedicated socket outlets utilised for critical application shall have the following features:

a) Distinctively coloured plug top covers, to distinguish the dedicated male plugs from domestic plugs. Unless otherwise specified, dedicated plug tops shall be red:

b) A graded series of shaved earth pins to facilitate the necessary discipline for plugging male plugs into corresponding female sockets. Unless otherwise specified, dedicated socket outlets shall be 0° shaved earth pin.

3-Phase Welding Plugs

a) The 3-phase outlets shall consist of 63A switched socket outlets and shall be of the 4-pin "Crabtree/ Clipsal" type or equivalent, complete with base and matching insert.

b) The construction shall be such that the plug can only be inserted the correct way.

c) The plug-in opening shall have a spring-loaded cover to prevent accidental contact with live parts.

29. Connections to Equipment

29.1 General

This section covers connections to equipment in general electrical installations under normal environmental conditions, up to system voltages of 600V.

29.2 Connections to Distribution Boards

Conduit Entries

Wherever necessary, conduits connected to distribution boards shall terminate in a common fabricated sheet-steel draw box, or wiring channel installed in the vicinity of the distribution board. In open roof spaces and/or electrical ducts, this draw box shall be placed in a roof space of not less than 900mm clearance. Lighting and plug circuits may be separately grouped in common conduits or metal ducts (trunking) from the distribution board to the draw box. The draw box shall be of sheet steel with a minimum thickness of 1.6mm and shall be provided with a removable cover plate.

Flush Mounted Distribution Boards

Where flush mounted distribution boards are required, the recessed distribution board tray shall be built into the brick or concrete wall. All conduits from the floor or roof shall be fully recessed and shall be bonded directly to the tray.

Cable Connections

Where underground cables have to be connected to distribution boards, it shall be the responsibility of the Contractor to ensure that sleeves are built in correctly to enable installation and connection of the cable to the switchboard. A metal cable duct with cover plate shall be installed from the sleeve to the switchboard and shall be painted the same colour as the switchboard. The sleeves shall be sealed with non-hardening compound after installation of cables to render the system vermin proof.

Cable Trenches

Where cables in floor trenches have to be connected to wall mounted distribution boards, approved sleeves or conduits shall be installed from the side of the trench to the bottom of the distribution boards.

These sleeves shall be positioned and fixed before the concrete is cast.

29.3 Connections to Motor Driven Equipment

An isolator, or starter containing an isolator, shall be installed within 2.0m of the equipment. The 0.3 requirements of SANS 0142 shall be met. If this isolator cannot be installed on a wall, board or other suitable place an approved free-standing pillar shall be provided. The pillar shall be 1.0m high and outside of normal walkways, etc.

The connection to the equipment shall be made as follows:

a) Metal reinforced plastic or PVC covered metal flexible conduits shall be used with individual conductors or a multicore PVC insulated cable and separate bare earth conductor installed inside the conduit. The flexible conduit shall not be longer than 600mm. Screwed conduit shall be used from the end of the flexible conduit to the isolator and/or starter.

b) Multicore armoured PVC insulated cable and separate bare earth conductor. The installation and termination of the cables shall be done in accordance with Section 4.8 of this document.

c) Cables and flexible conduits shall be provided with sufficient slack to allow positional adjustment of the equipment.

Supply cables to equipment shall not be installed across floors.

29.4 Connections to Heaters, Fans and Air Conditioning Units

Isolators

A flush mounted double pole isolator with a rating of 20A for units smaller than 3kW, and 30A for units with a rating between 3kW and 5kW, shall be provided within 1.0m of the unit and at least 1.5m above floor level unless situated in power skirting or a floor duct. Only where heaters or fans are mounted in easily accessible positions, and where an isolator switch is incorporated in the unit, may this isolator be omitted. Where flush isolators are employed, flush conduit shall be installed to link with the equipment outlet point. Flexible cords of sufficient rating may be used for the final connection to the equipment.

Wiring

The minimum conductor size to be used shall be 4mm². Each fan, heater or air conditioning unit shall be on a separate circuit.

Recessed Wall Heaters

The heater frame or tray shall be built or cast into the wall. Conduits shall terminate on the frame near the terminals. PVC insulated conductors may not be installed in the frame.

Surface Mounted Heaters, Fans and Air Conditioning Units

a) Connection points to surface mounted heaters and fans shall consist of a recessed draw box in the vicinity of the terminals of the unit. In workshops and industrial areas the connections shall be made by means of flexible conduit connected to dome lids on the draw box.

b) PVC insulated 3-core flexible cables ("Cabtyre") may be used for the connection.

c) Where "Cabtyre" is used, a bush shall be provided at the rear of the fan, heater or air conditioning unit for cable entry and a bush and clamp (or gripper gland) at the draw box. The clamp shall tightly grip the outer insulation of the cable to prevent tension on the connections between cable and conductors in the draw box.

Radiant Heaters

The installation of radiant heaters and asbestos heaters, where specified, shall comply with the requirements of paragraph 10.4.4 with the exception that they shall be mounted on spacers 25mm away from the mounting surface.

Unit heaters (i.e., combined fan and heaters) shall be mounted 2.25m above the finished floor level unless specified to the contrary and shall be firmly fixed by means of anchor bolts or by another approved method. Refer to the requirements of SANS 0142.

29.5 Connection to Cooking Appliances

Unless specified to the contrary, the circuit connection to each cooking appliance shall consist of 10mm² PVC insulated conductors and a 6mm² stranded earth conductor in conduit.

A flush mounted isolator shall be provided in accordance with SANS 0142. A white baked enamel cover plate shall be provided, situated wholly on the tiled or plastered surface where applicable.

Conduits shall terminate 450mm above floor level behind stoves. Connections from the conduit end to the stove shall be installed in accordance with SANS 0142. Sufficient slack shall be provided in the flexible connection to move the appliance 600mm away from its normal position for cleaning or maintenance.

Alternatively a 45A, 3-pin or 32A, 3-pin socket outlet may be mounted on a round draw box 450mm above floor level. The connection to the appliance shall consist of a plug and 10mm² or 4mm² PVC insulated cable. The cable shall be long enough to enable the appliance to be moved 600mm from its normal position for cleaning or maintenance.

Crimped lugs shall be provided on all conductors or cable cores for connections to cooking appliances. Soldered lugs may not be used.

Each appliance shall be connected to a separate circuit. A separate earth wire shall be provided for each appliance.

"The supply to each electric cooking appliance that is supplied from fixed wiring or through a stove connector shall have a readily accessible means of disconnection that is not fixed to, but is more than 3m from the appliance and is in the same room".

The following shall be noted in this regard:

a) A cooking appliance that is built-in shall not be supplied from a stove connector.

b) Although a maximum distance of 3m is permitted, the switch disconnecter shall be as close as practicable to, but preferably not above, the appliance and at a height from the floor of not less than 0.5m and not more than 2.2m.

c) If mounted more than 0.5m from the appliance, the purpose of the switch disconnecter shall be clearly indicated.

d) If a stove connector is used:

   i) the connector tubes shall point downwards, and

   ii) the conductors between the connector and the appliance shall be adequately protected from mechanical damage, e.g., by means of heavy-duty type sheathed flexible cord that complies with the relevant requirements of SANS 168, or by means of flexible conduit.

29.6 Connections to Hot Water Cylinders

Each hot water cylinder shall be served by a separate circuit with a separate earth conductor.

Each hot water cylinder shall be protected by earth leakage protection with $I_{\Delta n}$ not exceeding 30mA

The conduit from the switchboard to the cylinder shall terminate in a draw box within 1.0m of the cylinder terminals. The connection to the draw box may be conductors in conduit or PVC insulated cable. The connection between the draw box and the cylinder terminals shall consist of screwed metallic conduit. Only in instances where cylinders are mounted out of normal reach may flexible conduits and round boxes with dome lids be used for the final connection.

The following conductor sizes shall be used to connect cylinders up to 6kW capacity:

For cylinders with a capacity more than 6kW, details to be provided by the Engineer.

29.7 Connections to Clean Power Equipment

Connections to clean power shall only be made using components and methods to prevent the incoming clean earth conductor coming into contact with any portion of the domestic earthing system. Particular attention shall be paid to prevent equipment chassis earthing, earthing of outlet boxes, etc., coming into contact with any of the clean earth system components.

30. Earthing and Bonding of Distribution Substations and Generator Plant

30.1 General

The Earthing and Bonding of the substation electrical installation and extraneous conductive parts shall be in accordance with the regulations of the Code of Practice of the Wiring of Premises SANS 10142-1:2006.

The tenderers shall include in their prices for the supply, delivery to site, offloading and complete installation of the substation and Cable Earthing Systems, in strict accordance with the relevant Earthing Diagrams.

Should tenderers wish to offer alternative layouts, a full set of Detail Drawings shall be submitted with their tender for evaluation.

Cleated to surfaces of the MV switchgear, LV switchgear, Distribution Transformers, Voltage Transformers, Earthing Switches, Current Transformers and Generators, separate earth conductors shall connect equipment to the Substation Main earth bar and interconnect relevant equipment.

The main earth bars and substation earth mats shall be installed before any of the substation equipment is brought in for installation. The various Branch connectors shall be connected into the Earthing Systems with tails left at equipment positions for subsequent connecting-up.

30.2 Soil Resistivity

Soil Resistivity measurements shall be taken of the soils into which the proposed earth mats will be installed. Typically a Wenner four pin method is to be applied, making use of four electrodes driven into the soil to equal depth and equally apart. A suitable megger is connected to the electrodes in a predetermined sequence, the current is injected into the soil and resulting potential difference is measured.

The maximum soil resistivity of 50 OHMS shall be allowed, tenderers shall allow for additional extensible earthing for the improvement of soil resistivity.

30.3 Earth Mats

Substation earth mats are to be installed by others as shown on the Earth Diagrams and Layout Drawings. Substation main earth bars (wall mounted) shall be bonded with the earth mat by means of 95mm² stranded copper conduit Cu PVC insulated cable.

The earth mats systems shall conform with the following :

30.2.1 Material

Main earth mat	95mm² stranded copper
Secondary earth mat	70mm² stranded copper
Branch connectors	95mm² stranded copper PVC insulated cable

The earth rod system shall consist of ‘copper welded’ extensible (2m x 16mm) earth electrodes interconnected by 70mm² stranded copper conductor.

Depth of Installation	1000mm below finished ground level
Method of Installation	Direct in the ground

30.4 Branch / Bonding Connectors and MV Cable Earths

The following Branch connectors shall be installed :

30.4.1 Medium Voltage (refer to earthing diagrams)

a) MV switchboard bonded to relevant transformer tank – 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3)

b) MV switchboard earth bars bonded to main substation earth bar – 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3)

c) MV switchboard 1 bonded with MV switchboard 2 – 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3)

d) All transformer tanks shall be bonded – 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3)

e) MV switchgear earth bar shall be bonded to metal clad enclosures – 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3)

f) Incoming 11kV cable earth conductor (installed in ducts) shall be connected to substation main earth bar – 95mm² annealed stranded Cu conductor PVC insulated (yellow/green) to SANS SANS 1507-2.

g) Incoming 11kV cable armouring shall be solidly bonded to relevant switchgear earth bar

h) MV switchboard metal clad enclosures to be bonded to switchboard earth bar

i) MV switchboard and transformers to be installed with “Teco Pad” insulation

30.4.2 Medium Voltage (refer to earthing diagrams)

a) Transformer star point shall be connected to main substation earth bar by means of – 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3)

b) Transformer star point shall be bonded with other transformer star points by means of – 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3)

c) Transformer star points shall be connected to relevant LV switchboard by means of - 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3)

d) LV switchboard earth bars shall be bonded by means of 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3)

e) LV switchboard earth bar shall be connected to switchboard metal enclosure

f) LV switchboards to be installed on “Teco Pad” insulation

30.4.3 Generator Earthing Requirements

All generator star points and frames shall be connected to a separate insulated “generator” earth bar by means of 95mm² 1 core Cu PVC insulated and sheathed cable. The earth bar shall be a wall mounted (fixed on insulators) copper earth bar : 500mm x 60mm x 12mm and shall be connected to the Generator LV

switchboard by means of 95mm² 1 core PVC insulated and sheathed cable. (Please refer to Substation No. 5 earthing diagram.)

30.5 Earth Conductor Joints, Intersection Bonding and Terminal Connectors

All joints shall be Exoweld connectors using Exothermic-welding power. The power is available from Exoweld, but any other type or supplier may be chosen provided full details are submitted to the Engineer for his approval.

Before the metals are brazed, both surfaces shall be sand papered clean and shall be heated to the required temperature sufficient to enable the brazing material to flow between the surfaces and so ensure, through adhesion a complete metallic bond is required.

30.6 Terminal Connections

Earth Terminal lugs shall be a Torque-controlled, shear-head bolt type (IEC61238-1) suitable for 95mm² 1-core Cu PVC insulated and sheathed (SANS 1507-3) cables. Each bolted connection shall also include two bronze clamping bolts and nuts with flat and spring washers.

30.7 Substation Earth bars

Each substation shall be fitted with a wall mounted (fixed on insulators) copper earth bar : 1000mm x 60mm x 12mm.

Medium and low voltage switchgear, transformers as well as the MV cable earth shall be connected to the main earth bar as the main earth bar connected to the substation equipment.

Earth bars shall be constructed with the Test links to isolate local earth mats from the earthing systems.

30.8 Recording of Earth System Resistance

The substation earth resistance shall be measured immediately upon completion of the earthing installation BEFORE the substation equipment is installed.

Final reading shall be taken upon completion of the substation, when fully installed the earth resistance shall not exceed 1 Ohm. The final resistance measurement shall be with MV supply cables disconnected from the earth mat.

30.9 Earth Monitoring System

All transformers and generator star point earth connections shall be fitted with an earth monitoring system. This system shall consist of:

- Ammeter with pre-settable potential free contact and 4 to 20mA output.
- 100/50/5A Class 10P10 ring type C.T. suitable for earth wires up to 120mm².
- Insulated terminal rails.
- 230V power supply.
- York box with lockable 1-hinged front cover, wall mounted via 2000V dumpy insulators. (refer to earthing diagram.)

31. Diesel Generators

31.1 System Description

The standby electrical power for the building shall be provided at 400V using a diesel driven generator set.

The system shall consist mainly of;

Diesel driven generator
Control and changeover
Acoustic attenuation
Fuel storage and supply
Exhaust

31.2 Standards

Where applicable, equipment shall comply with the latest edition and amendments of;

IEC 60034-22:1996 / SANS 60034-22 : Rotary Electrical Machines – Part 22: AC Generators for reciprocating internal combustion engine drive generating sets.
ISO 8528-1:2005 : Reciprocating internal combustion engine driven alternating current generating sets
ISO 15520:2002 : Internal combustion engineers – Determination and method for the measurement of engine power
BS 5514-4:1997 : Reciprocating internal combustion engine performance and speed governing

31.3 System Operation

31.3.1 Functional Overview

The diesel generator set will start automatically in the event of mains failure. Once the set is available to accept load, the changeover system will switch the load on to the generator.

Changeover is located remotely in the main LV panel, and controlled by the generator controller.

31.3.2 System Requirements

Pre Delivery Information

Within four (4) weeks of receipt of the purchase order, the tenderer shall submit for the Engineer's review, comment and approval.

Fuel/emissions strategy;
Details on full range of attachments;
Finalised schematic diagram and dimension drawings;
Generator operating characteristics as protection/control devices;
Shipping/transport details

Site Dimensions, Levels and Tolerance

The Supplier is to ascertain all relevant site dimensions, floor levels and tolerances before commencing, and in carrying out the work.

On line testing

The diesel powered generating sets will also be required to operate in parallel with the mains for short periods of time, i.e. up to 100 msecs, in order to be able to test the generating plant with the system load and without any break in supply to consumers.

Equipment supplier's approvals

The suppliers of the equipment must be made aware of the online testing facility and must formally confirm that the equipment supplied is suitable for the duty (i.e. the voltage distortion due to the step load is not to exceed 10% of the nominal voltage).

Alternator supplier/manufacturers are also to be made aware of the transformer inrush current requirements for installation with step up transformers so that the integrity of guarantees and equipment warranty is not prejudiced.

Any performance or paralleling limits constraints imposed by equipment suppliers in this regard must be formally and unequivocally stated at the time of tendering.

Total harmonic distortion

The set loading is defined in the load schedules and consists principally of UPS's, fluorescent lighting, fan motors, and thyristor drive lift motor drives. The equipment shall be capable of handling these loads with the on load output voltage THD limited to 5%.

Automatic starting and change over

Start and shutdown signals for the generating sets is either via a potential free contact in the Main LV boards and/or a phase failure relay located in the generator control panel sending from the battery charger power supply.

31.4 System Equipment

31.4.1 Engine

Engine Selection

Engine speed shall be 1500 r.p.m.

The engines shall be adequately rated for continuous full load operation at the specified load when operating on site in the location indicated on the drawings, and shall be selected and engineered to suit the dynamic characteristics of the load equipment.

The successful tenderer may be required to submit torsional vibration analysis calculations to substantiate the compatibility of the engine and driven equipment. Alternatively, approval certification from the relevant equipment manufacturers in this regard.

The torsional vibration analysis calculations shall be in accordance with Part 5 Chapter 8 of Lloyds Register of Shipping Rules and Regulations for the Classification of Ships.

The engine crankshaft/alternator shaft and coupling selection shall be such as to withstand the maximum stresses induced under multiple alternator short circuit or transient load conditions without fatigue or failure of any part of the system.

Tenderers are to complete the schedules indicating the derating factors applied to the engine to suit the ambient conditions. Derating is to be strictly in accordance with the relevant standard specifications.

Engines shall as a minimum comply with the Tier 3 emissions standards as defined by the United States Environmental Protection Agency (EPA) or the equivalent European Stage IIIA Standard.

Engine Starting

Engines shall be suitable for direct current electric motor starting in accordance with the following specification and the schedule of requirements. Compressed air starting may be offered as an economic alternative.

The system must incorporate the following:

Long life sealed type starting battery banks of adequate capacity;
An automatic mains/standby supply operated battery charging facility;
Direct current series/shunt wound commutator starter motor with associated solenoid switch;
Suitable moving coil AM class volt meters and centre zero (charge/discharge) ampmeters indicating the battery as well as charging/voltages and currents.

The battery charger is to be approved by the battery supplier and full details of the battery charger, charging cycle relative to the type of battery being used are to be provided for approval by the Engineer. Details required are as follows:

Initial charge rate and duration. Volts/Amps/Time;
Intermediate charge rate and duration if applicable. Volts/Amps/Time;
Long term continuous trickle charge rate and duration. Volts/Amps/Time

The above information is to be related to the charge/discharge curve of the battery system. Furthermore the battery supplier is required to formally confirm that the indicated trickle charging will not be detrimental to the battery cells.

Full manufacturing details of the charger as well as ratings of all components are to be provided for approval and inclusion in the manuals.

The highest output voltage of the charger and battery system must be within the voltage tolerance of the control equipment being used in the diesel generator control panel. The rating of this equipment and the relevant voltage tolerances are to be submitted for approval. The battery charger shall be equipped with a battery charger failure output alarm contact via a normal energised relay.

Volt meters and ampmeters for use on direct current systems must be scaled so that readings to within 1,0 volt and 1,0 amp may be accurately read. Accuracy to be within 0,5% at any position between 10 to 125% of full scale.

Batteries may be housed on the engine frame/support skids or accommodated in the control/switchboard.

Battery frames/housings/cubicles are to be manufactured from corrosion-resistant material.

Batteries are to be sized to provide four consecutive cranking cycles of at least 20 seconds on and 10 second off duration, and to supply 150 VA continuous base load to the switchboards auto/alarm control system or larger as required by the control system, and also be capable of handling a transient 900 VA demand for 40 milliseconds. As a minimum the batteries must not be less than 180 Amp hour capacity.

Engine Auxiliary Equipment and Accessories

Engines are to be supplied complete with water jacket heaters and isolating valves (together with circulating pumps as may be necessary) to maintain engine temperatures for easy starting during summer and winter under all ambient air conditions. The heaters are to be automatically controlled via thermostats and electrical supplies thereto are to be provided by the Contractor from the diesel control panel.

Engine oil heaters may not be employed under any circumstances.

The engine must be supplied complete with all accessories and auxiliaries necessary, a standard set of tools sufficient for all usual routine maintenance work, instruction manual, recommended spare parts, etc. These items must be detailed at the time of tendering.

Engine Storage and Preservation

Where the period between date of manufacture and date of start-up of the engine exceeds 90 days, the contractor will be required to provide full details of the engine preservation procedures and precautions, carried out by the supplier.

The costs for the above are to be included in the tendered price.

Engines are to be shipped, sealed in moisture proof packing that totally enclose the engine, e.g. heavy duty shrink wrap or alufoil/vacuum wrap.

31.4.2 Fuel Systems

Fuel lines are to be of stainless steel. Both fuel lines and injection system shall be suitable for operation with commercially available brands of South African diesel fuel.

A fuel storage tank capable of running the set/s at full load for a minimum of 8 hours shall be provided unless otherwise specified.

A wall mounted electrically operated pump shall be provided for transfer of fuel from 240 L drums.

31.4.3 Governors

Governors shall be of the Woodward or G.A.C. Electronic type. The governor must be capable of maintaining the permanent and transient speed regulation and recovery times within the limits specified when the engine rated load is switched on and off in one step and when the set is operated in conjunction with the number, size and type of steady state and transient loads specified.

31.4.4 Lubrication

An automatic low oil pressure and high temperature cut-out must be fitted operating the stop solenoid on the engine and giving a visual and audible indication on the engine control panel.

31.4.5 Cooling

The engine may be air or water cooled. A heavy duty, tropical type pressurised radiator must be provided for water cooled sets and air cooled sets must be supplied complete with air ducting to the outside. The radiator fins/tubing for water cooled sets are to be of copper/brass construction.

Protection must be provided against running at excessive temperatures. The operation of this protective device must give a visual and audible indication on the engine control panel.

Tenderers must allow for the necessary drain valves, air bleed-off valves and expansion tanks.

The cooling pipe system must be engineered so that the water jacket heaters are not used excessively to maintain temperature, due to the thermal siphon effect between radiator engine and block.

Water cooled sets are to be fitted with suitably treated water containing corrosion inhibiting additives approved by the engine manufacturer.

31.4.6 Fly Wheel

The fly-wheel selection must contain the cyclic irregularity of the set to within the limits laid down in the standard specifications.

Furthermore, the set must be provided with a suitable vibration damper on the crankshaft to ensure vibration free operation at all loads and to cater for micro alignment irregularities.

31.4.7 Exhaust

If fuel lines pass over them, manifolds are to be clad/lagged in a heat insulating material and are to be shrouded in metal to protect against leaking fuel dripping onto a hot manifold. Alternatively, water cooled manifold systems may be employed.

Exhaust pipes are to rise vertically to ceiling/soffit height of the plant room and transfer in the horizontal plane to penetrate the side wall/slab over at high level. The system is required to be as short as possible with a minimum number of bends. Bends are to be wide radius right angle bends.

Exhaust pipes are to be manufactured from stainless steel and are to be connected to the exhaust manifold via a stainless steel flexible bellows type coupling with bolt on flanges.

The exhaust pipe is to be insulated along its length in the plant room with a minimum of 50 mm thick insulating wool or other approved means and clad with aluminium sheeting overall to reduce heat rejection within the plant room.

Silencers are required and shall likewise be clad to limit heat rejection within the plant room.

Silencing is to meet the Local Authority requirements in all respects and the contractor must obtain any necessary approvals in this regard.

31.4.8 Air Filters

Air filters shall be of the dry element type which incorporate an air restriction indicator. It shall be possible to remove and replace elements without disturbing the filter mounting arrangement or adjacent equipment.

31.4.9 Protection, Control and Alarm Devices

Unless otherwise specified, the following will be regarded as a minimum requirement:

Relays for protection requirements shall be fitted to give a visible signal as to cause and to stop the engine when any of the protective devices operate.

Protection must be provided for high engine temperature, low lubricating oil pressure, overspeed and start failure as a minimum requirement.

A re-set push button must be provided which on operation, after correction of the fault, resets the control system to allow re-start in accordance with the selected control position. The reset is to be non operative if the fault remains uncorrected.

A push button must also be provided to cancel the alarm signal. This push button is to be suitably labelled.

Transient protection by pass circuits required during the run up cycle must be of the failsafe type.

31.4.10 Alternators

The alternator shall be capable of supplying the specified steady state load continuously and accommodate the starting loads listed on the schedules. Temperature rise shall not exceed the limits for Class E insulation levels, and the machine shall be capable of sustaining an overload or short circuit of 300% full load for 3 seconds.

All windings shall be fully impregnated for tropical and coastal climates and must have an oil resisting type of insulation complying with Class H.

The alternator is to be provided with anti-condensation heaters and associated thermostatic control as necessary.

The inherent steady state voltage regulation for all loads and load power factors between zero and through unity to 0,8 lag and for the specified maximum speed variations, shall not exceed 1,5% over or below the predetermined manually set open circuit nominal voltage value. The alternator and excitation system shall be able to meet the steady state and transient voltage dip performance specified for all loading conditions. Unless otherwise specified the permanent magnet generator type excitation system shall be designed to promote rapid voltage recovery following the sudden application of full load. Transient voltage dips shall not exceed 15% of the steady state nominal voltage value and shall recover to within 1,5% of the nominal value within 250 milliseconds.

The alternator shall comply with the following requirements unless otherwise specified in the schedule of requirements.

Permanent magnetic generator excitation system with three phase voltage sensing and automatic voltage regulation;

2/3 Pitch factor winding to eliminate triplen harmonics with skewed core to eliminate slot ripple;

Total harmonic open circuit voltage distortion to be limited to less than 1%;

Total harmonic three phase balanced load distortion to be limited to less than 2.5%;

Telephone interference limited to less than 2%;

As a basic mandatory requirement, protection against short circuit and overload is to consist of a Heineman Mitsubishi or Merlin & Gerin, type thermal and magnetic release fitted to a suitably sized circuit breaker. The supplier shall confirm, by means of an overcurrent versus time characteristic comparison of the machines withstand capability and the protection device characteristic, that the alternator will be satisfactorily protected by these devices. Alternatively, tenderers shall provide other means of providing adequate alternator overload and short circuit

protection with the relevant substantiation at tender. In addition inherent A.V.R. protection against over excitation caused by internal or external short circuits by means of integral automatic field isolation facility;

Over voltage protection inherent via a suitable overvoltage module or externally via a set management system. This must be adjustable as to voltage and time and must trip the alternator circuit breaker;

Enclosures shall be to IP23. Should this incur a cost penalty, details must be made available at tender and an optional price for an IP23 enclosure given;

The alternator shall be directly coupled to the engine by means of a first class quality flexible coupling;

The alternator cable boxes must be suitably sized and designed for PVC SWA PVC cabling and water tight C.C.G. type cable glands.

31.4.11 Control Panels for Diesel Generating Sets

A control panel shall be supplied and incorporate all equipment necessary for the control and protection of the generating set and the battery charging system. This may form part of the switchboard or be set mounted.

The control panel shall comply with the Low Voltage Distribution Board and Motor Control Centre in all respects.

The panel shall be free standing. All equipment is to be mounted within the panel, and connections and terminals shall be easily accessible. The front panel must be hinged. Self-tapping screws and hidden i.e. captive nuts may not be used.

Out-going cable termination facilities are to be completely shrouded from any live wiring, terminals or busbars. The live incoming cable termination facilities are to be located in separate panels to outgoing terminations, or are to be effectively shrouded against inadvertent contact.

All control, protection and alarm wiring shall be fitted with a cable or wire marker of approved type at each end and the numbering of these markers must be shown on the wiring diagram of the panel. Only the address system of cable marking will be acceptable. Control and alarm circuit wiring shall be suitably colour coded to distinguish from power wiring. eg. Black shall only be used for negative and neutral connections, and Green or Green/Yellow for earth connections.

The use of fuses shall be minimised and only Merlin Gerin or other approved circuit breakers will be acceptable.

All incoming and outgoing wiring shall be wired to terminal strips and connectors, and shall not be terminated directly on equipment within the board.

Power equipment, busbars and wiring shall be kept physically separate from control and alarm wiring and equipment, and housed in a separate enclosure.

Labels and designation tags are to be screw fixed. Glue fixing or self-adhesive labels are not acceptable.

An earth bar must be fitted in the control panel, to which all non-current carrying metal parts shall be bonded. Single point isolation of the panel is required and all necessary warning labels are to be provided.

31. 5 Installation

31.5.1 Site Dimensions, Levels and Tolerance

The Supplier is to ascertain all relevant site dimensions, floor levels and tolerances before commencing, and in carrying out the work.

31. 6 Testing and Commissioning

The various sections of the standard specification indicate the routine tests required. These are to be regarded as a minimum requirement. Additional requirements are given in the Project Specification and the drawings/schedules/summaries.

In the event of the plant or installation not passing the tests, the owner shall be at liberty to deduct from the contract price any reasonable expenses incurred in having to repeat the tests.

The preliminary tests shall be carried out as necessary to ensure that the plant, materials and equipment comply with the provisions of the contract and are in a suitable state to satisfy the requirements of the specification. These preliminary test results are to be recorded (in a manner to be agreed with the Engineer) and submitted to the Engineer attending the acceptance tests.

If the tests are not undertaken within a reasonable period of time, the Owner may arrange to have the tests performed by others. All tests so made shall be at the risk and expense of the Contractor.

Upon satisfactory completion of the final inspections and acceptance tests, a hand-over certificate shall be issued accepting the plant and equipment on behalf of the Owner. Until handover occurs, the whole of the contract works will remain the responsibility of the contractor.

31.6.1 Factory Tests

Each generator set will be tested under varying loads with guards and exhaust system in place.

The Factory Tests shall include:

Single-Step load pick up;
Transient and steady-state governing;
Safety shutdown device testing;
Voltage regulation;
Rated power;
Maximum power.

Upon request, arrangements to either witness this test will be made, or a certified test record will be sent to the Engineer prior to shipment

31.6.2 Site Tests

On completion, erection and installation of the generators, panels and all associated hardware, the tenderers shall perform test specified. Tenderers to provide their own test equipment. Test equipment shall be of an acceptable standard.

Testing the diesel generator sets in conjunction with the services such as UPS's, lighting, lifts, escalators, pumps and general essential loads.

Testing the diesel generator sets at practical completion of project in presence of the Client and Local Authority fire department.

The Site Tests shall include:

Fuel and lubricating oil shall be checked for conformity to the manufacturer's recommendations, under the environmental conditions present and expected;

Accessories that normally function while the set is standing by shall be checked prior to cranking the engine. These shall include: block heaters, battery charger, generator strip heaters, remote annunciator etc;

Start-up under test mode to check for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage, and phase rotation;

Automatic start-up by means of simulated power outage to test remote-automatic starting, transfer of the load and automatic shutdown. Prior to this test, all transfer switch times shall be adjusted for proper system coordination. Engine coolant temperature, oil pressure, and battery charge level along with generator voltage, amperes, and frequency shall be monitored throughout the test. An external load bank shall be connected to the system if sufficient load is unavailable to load the generator to the nameplate KW rating.

31.6.3 Witnessing of Tests

The engineer reserves the right to be present at any of the tests specified (factory or site tests). The Engineer shall be notified in time (2 weeks notice) to enable him to attend the tests should he wish to do so.

The tenderer shall replace any part of the generator installation should it be found not compliant with the specification, during tests or inspections. The replacement of any parts shall be for the Tenderer's cost.

No generator set shall be dispatched from the manufacturer's works without the Engineer's approval of its testing and overall quality.

31.6.4 Test Certificates

Two copies of test certificates shall be supplied to the Engineer prior to the sets being delivered to site.

A copy of the factory and on site test certificates shall be incorporated into each maintenance manual.

32. Uninterruptible Power Supply

32.1 System Description

32.2 Standards

32.2 System Requirements

32.2.1 Output to Load

Rating	Refer to detail specification.
Output voltage	Refer to detail specification.
Output Frequency	50 Hz ± 0,5 Hz.
System	1 phase 2 wire or 3 phase 4 wire with operative earth conductor.
Voltage regulator	± 10% maximum deviation of steady state voltage recovering to within 5% in less than 50 ms and to within 1% less in that 100 ms.
Frequency stability	Normally automatically synchronised to mains frequency if the latter is within 50 Hz ± 2% (adjustable window) Runs free at 50 Hz ± 0,5 Hz at any load when mains is out of limits.
Harmonic content	Less than 4% total distortion.
Amplitude modulation	Less than 2%
Efficiency (overall)	80 - 85%

32.3 System Description

The system shall consist of a static UPS complete with the following components :

(a) Rectifier/charger.

(b) Inverter.

(c) Battery.

(d) Automatic electronic no-break bypass circuit and switch.

(e) Separate manual bypass switch.

(f) Protective devices and measuring equipment.

(g) The required controls and necessary equipment.

(h) A self monitoring system with digital readout by means of which all critical functions can be checked.

The system shall be capable of providing an uninterrupted supply to the load with the output characteristics as specified a total mains failure (i.e. normal mains and standby generator supply failure). The batteries shall be rated at an AC load power factor of 0,8 lagging.

The complete system, including all controls shall be designed in such a way that the failure of any one vital central component will **NOT** cause a complete system failure. If necessary such a failure must be avoided by connecting the load directly to the mains by means of the bypass switch.

The UPS shall operate satisfactorily synchronous with the mains supply even under severe conditions of up to 100% unbalanced load.

The UPS shall be amply rated to carry the stated full load current. The UPS shall furthermore be capable of withstanding the following overloads.

Static Overloads:

- 100% of full load continuously.
- 125% of full load for 5 minutes.
- 150% of full load for 2 minutes
- 165% of full load for 1 second with inductive decay after initial equipment switch on surge current.

Dynamic Overload :

- 300% for less than 5 msec.
- 1000% for less than 1 msec.

All component parts, cables and other connections shall be amply rated to withstand the overloads stated and maintain the input voltage **at the load** within the tolerances stated.

The equipment shall be designed for the maximum operating efficiency. The efficiency shall be determined when the system is delivering full load at 0,8 power factor with the batteries fully charged. The load required by the auxiliary equipment (controls, alarms, etc). electronic switches and cabinet fan shall be included in he determination of overall efficiency. A typical test report clearly showing how the efficiencies are calculated, shall be submitted with the tender.

It shall be the responsibility of the successful tenderer to ensure satisfactory operation of the complete system for the load to be supplied. It is, therefore, essential that the tenderer acquaint himself fully with typical load conditions before the tender closing date.

All cabinets containing thyristors shall be adequately screened and earthed to prevent direct radio frequency radiation.

Tenderers shall submit with their tenders a schematic diagram showing :

Input circuit breakers.
System busbars.
Rectifiers.
Batteries.
Inverters.
Electronic switches.

Bypass circuit.
Detour circuit.
Fuse protection.
Output circuit breakers.
Oscillator.
Power supply circuits to oscillator, alarms, controls, etc.
Battery isolator.

32.3.1 Rectifier

The UPS shall have its own rectifier and rectifier transformer which shall operate satisfactorily from the mains or standby supply.

The rectifier shall be of the solid state type providing full wave rectification of the input voltage suitably regulated to suit the input requirements of the inverter. Where necessary, a high grade DC filter shall be utilised to limit the output ripple to within acceptable levels for the inverter input. Current limiting features shall be provided to protect the rectifier. The current limiting settings shall be variable for final adjustment on site.

Voltage free contacts shall be provided for the malfunction alarms of the rectifier.

An input monitoring circuit shall be provided for the rectifier. This circuit shall switch off the rectifier when the r.m.s. value or frequency of the input voltage falls below present values.

The necessary protection circuitry shall be provided to switch off the rectifier if any one of the rectifier phases should fail, thus presenting an unbalanced load to the incoming supply.

The output of the rectifier shall be connected in parallel to the battery and inverter.

The rectifier shall have over temperature protection. Temperature sensing probes shall be placed on the thyristor housing, thyristor mounting, or on the heat sink close to the thyristor. The sensing of the off coming air temperature alone is not acceptable.

Tenderers shall take into account the possible effects of harmonics that may be present on the input supply due to non-sinusoidal waveforms at the rectifier input, phase commutation, the effect of reactance during phase commutation etc. The input voltage monitoring circuits of the rectifiers shall be adequately filtered and buffered to ensure reliable load control and to prevent continuous on-off switching of the rectifiers.

For three phase units each of the three rectifier transformers shall have a different primary to secondary phase displacement in order to minimise the harmonics generated by the rectifiers.

32.3.2 Inverter

The inverter shall be adequately protected against any excessive overload or short circuits that occur in the load. Reactive current limiting or other methods shall be employed to render the thyristors short circuit proof. The successful tenderer shall replace any thyristors or any inverter components at his own expense if these should be damaged.

The necessary feedback and control circuits shall be incorporated to ensure satisfactory operation separately or in synchronisation with the mains supply under all conditions of dynamic load variations, stated overloads, severe unbalanced conditions and high operating temperatures. The thyristor bridge shall contain the necessary auxiliary circuitry to ensure satisfactory operation.

The output of the inverter shall be connected in parallel with the thyristor switch output.

Each inverter shall have over temperature protection similar to the over temperature protection for the rectifier.

A discharge device shall be provided across the D.C. input to the inverter, which will discharge any capacitors in the inverter module when it is switched off.

The inverter shall contain an oscillator capable of operating and maintaining the inverter output frequency as specified. The inverter oscillator shall be capable of frequency synchronisation and phase locking to the mains (or standby generator) power source frequency. When operating as a slave to the mains or standby power and a failure occurs in the slaving signal, the invertor oscillator shall automatically revert to a free running state and maintain the specified limits. All changes in output frequency to free run or synchronise shall be gradual to suit the load requirements.

32.3.3 Battery charger

The battery charger shall be a solid state, constant voltage type providing full wave rectification of the input voltage with the output regulated to an accuracy as specified. A high grade D.C. filter shall be utilised to limit the output ripple to the stated tolerance. Current limiting features shall be provided. The value of the current limit setting, shall be in accordance with the maximum allowable charging current that the batteries can withstand.

The maintained voltage on float charge shall be such as to give maximum life to the batteries whilst maintaining the maximum charge conservation and minimising gas formation and water loss. The optimum float charge voltage shall be specified by the battery manufacturer but is expected to be approximately 2,23 volts per cell. The voltage shall be kept within ± 0,5% of the nominal value for all loads from no load to the full rated battery charger current when supplying the full output with batteries discharged.

32.3.4 Battery

The battery capacity shall be sufficient to provide full load for the specified time. The capacity shall be rated at a maximum specific gravity of 1,245 at 25 C and correctly filled.

Tenderers shall state the discharge capacity of the battery after 10 hours of charge and the battery voltage at its terminals under various conditions. The inverter shall switch off on low battery voltage.

The battery cells shall be of the maintenance free type.

The batteries shall give satisfactory service for a minimum period of **3 years**. Tenderers shall state the maximum expected lifetime of the batteries and motivate their statement, and provide a statement by the battery manufacturer supporting this and stating that the charger offered is suitable for the battery.

The cells must be mounted in a matching steel cabinet or in the same cabinet as the control equipment. The vented type cells should be mounted on a wooden stand, consecutively, numbered with positive and negative terminals clearly marked in a ventilated battery room.

The batteries shall be complete with cell inter-connectors and row inter-connectors. The output terminals shall be robust and adequately dimensioned for the output cable terminations.

The inter-connectors between cells and shall be made in a manner giving the lowest volt drop and maximum resistance to corrosion.

All connections to cells must consist of flexible cable to avoid mechanical stress at the cell terminals.

The tenderer shall describe the method of removal and replacement of a faulty cell.

The battery shall be complete with a battery fuse isolator capable of breaking the full load current drawn by the inverter. These battery fuse isolators shall be installed in the inverter unit room or cabinet.

Terminal posts should be effective for the expected lifetime of the battery and should be effective even if the cell is overfilled.

The battery may be resistance grounded through 5000 ohm to 10000 ohm for the purpose of ground fault.

Tenderers shall submit full details with dimensioned drawings of the batteries offered.

Tenderers shall submit the calculations and motivations complete with curves supporting the selection of a specific battery cell.

All cabling for the battery shall be installed on PVC cable trays and fitted to the satisfaction of the engineer.

32.3.5 Automatic by-pass switch

An integral automatic bypass switch shall be provided to transfer the critical load without break to the mains should the UPS unit fail. The latter unit shall simultaneously be disconnected from the critical load bus. This transfer shall, however, be inhibited if the mains is out of synchronism with the UPS output. Retransfer to the UPS output shall be on a manual or automatic command. This switch must have a cover fitted screwed to the panel so as to make the operating of this switch impossible without having first removed the cover.

The static switch should prevent "hunting" and after trying unsuccessfully to switch a maximum of **three** times the static switch should be inhibited from further switching.

32.3.6 Computer Rooms / Office UPS Installation

The rectifier shall be equipped with **2 independent** over voltage shutdown contacts for maximum charger security.

The battery charger shall be designed to charge the batteries to 90% of its fully charged capacity within 14 hours and to 100% capacity within 20 hours.

The battery charger shall be capable of boost charging the batteries to 2,6 volt per cell. The boost facility shall be manually operated.

The battery charger shall be provided with a current limiting circuit.

The current limit setting shall be variable for easy adjustment on site.

The necessary voltage free contacts for the alarms and battery charger failures shall be allowed for in the tender price.

The battery charger shall have over temperature protection similar to the protection specified for the rectifier.

The battery charger shall have circuitry to inhibit the charging of batteries from the standby generator. This circuitry shall be activated by normally open contacts on the generator control panel. The interconnecting cables will be supplied and installed as part of this contract.

32.3.7 Construction of Cubicles and Switchboards

All the converter equipment shall be housed in totally enclosed, free standing, floor mounted cubicles, designed top provide adequate ventilation for the equipment.

All cubicles shall be rigid with suitably braced doors providing front access.

All cubicles shall be vermin proof.

All equipment shall be mounted on the metal framework suitably arranged to provide safe operation and ease of access. Fuses and switchgear in particular should be safely accessible even under load conditions.

All power bridges, filters and other major components both in the inverter and rectifier, shall be completely withdrawable to facilitate rapid repair and/or replacement. The method of withdrawal shall be such that a complete module can be extracted in the operating condition so that checks and measurements may be made while in operation and access to all components facilitated.

All electronic printed circuit cards shall be of a good quality and shall be easy and simple to interchange.

All auxiliary power supplies shall be duplicated and shall be connected so as to operate in parallel redundancy. At least two primary sources of power shall be provided for each of the power supplies in the system.

Flexible wires shall not be soldered directly onto terminals but shall have a crimped tab, which is soldered onto a terminal or post. The wire wrapping technique shall be employed for electronic circuits where possible.

The front panel alarms shall be clearly and adequately marked. A single line mimic layout of the switchgear shall be provided on the front of the cubicles providing a graphic display of the circuitry of the equipment involved.

32.3.8 Instrumentation and Controls

Facilities shall be provided for controlling the rectifier, switching the inverter on, switching the inverter output to the synchronous motor/alternator and controlling the bypass thyristor switch circuit.

All control switching of the rectifier and inverter as well as the bypass operation shall be pushbutton initiated.

Electronic equipment be protected with transsorbs and metal oxide varistors in power supplies and external communication lines.

32.4 Alarms

All alarms shall be of the tell tale type with memory features e.g. a flashing light indicates a fault coupled with an audible alarm. The pressing of the appropriate button shall cancel the audible alarm and allow the alarm lamp to burn continuously until the fault is removed.

The following minimum alarm conditions shall be monitored on the equipment:

- Normal
- Mains failure
- Inverter failure
- Shutdown imminent
- Load on mains
- Overload
- Charger fails

Where required a remote panel must be supplied and installed. The alarms indicated must duplicate all the alarms indicated on the UPS control panel. In addition a buzzer must be provided. Any alarm occurring must sound the buzzer to draw attention. An alarm accept pushbutton to silence the buzzer must be provided.

Provision shall be made on all the alarms mentioned above to be remotely monitored. Normally open contacts shall be supplied at the converter for each alarm for this purpose. The contacts shall close under an alarm condition.

32.5 Ventilation

All equipment racks shall be positioned in logical fashion on the floor in a configuration, which will ensure proper ventilation

Each cubicle containing heat-generating equipment (thyristors, transformers electronic circuitry, filters, etc) shall, where necessary, have extraction ventilation fans mounted on the top of the cubicle to assist air circulation. These fans shall be fed from the output distribution panel of the uninterrupted power supply.

32.6 Tests

The complete testing including the provision of test facilities, instruments, dummy loads and switchgear at the manufacturer's premises shall form part of this contract.

For the test in the manufacture's premises the client shall be notified four weeks in advance in order that a representative can be sent to witness these tests.

32.6.1 Battery Tests

a) The output voltage of the battery unit (i.e. all the cells making up one battery) shall be tested with the incoming supply removed.

b) The full rated load for the battery shall then be connected to it. The voltage shall be measured at 5 minute intervals for the duration discharge period.

c) The batteries shall be left to recharge. The voltage shall be checked after 14 hours with the load and incoming supply removed as well as with the load connected but incoming supply removed.

d) When fully recharged, the voltage and specific gravity of every cell shall be measured with the incoming supply removed.

e) The circulating A.C. current through and the A.C. voltage across the batteries shall be measured when the rectifiers are on with the battery discharged and fully charged.

32.6.2 Oscillator tests

a) Frequency within tolerances at all loads.

b) Parallel redundancy.

c) Auto automatic synchronisation for connection of the synchronous motor/alternator to mains via the thyristor switch.

An electronic frequency counter shall be used to measure the frequency.

32.6.3 Rectifier tests

a) Output voltage of rectifiers at no load and full load with batteries charged and not charged.

b) Current limit, both for mains failure and return to mains.

c) Switch off value mains input monitor.

d) Sequential switch on for return to mains.

e) Soft start circuits.

32.7 General

Ammeters will not be acceptable to prove the above items. A wave analyser and a recording oscilloscope will be required. Photographs shall be taken of the oscillograms by the contractor in the presence of the engineer.

The overall efficiency of the complete uninterrupted power supply shall be proved to be within the specified limit at full load and at no load.

The overcurrent protection mechanisms of the A.C.B. shall be proved by current injection (either primary or secondary)

The bypass and detour circuits shall be proved.

All alarms, indications and control functions shall be proved.

The test instruments provided shall in all cases be of high quality and suitable to be able to adequately assess the quantities being measured and the equipment being tested. All instruments shall be calibrated by a testing laboratory approved by the National Calibration Service of the CSIR. The test equipment remains the property of the successful tenderer.

At the completion of the tests, a full test report shall be submitted by the contractor to the engineer in triplicate.

Continuously adjustable dummy loads of a rating suitable to comprehensively test the UPS shall be provided by the contractor as well as any temporary cables required for the connection of the dummy load to the UPS on site.

32.8 Cabinet

The contractor shall supply and install a metal cabinet with lockable doors of sufficient size to house all operating and maintenance instructions, drawings, spares, tools, etc.

32.9 Schematic Diagram

A schematic diagram of the complete system shall be mounted in a suitable place and shall be resin encapsulated.

32.10 Auxiliary Equipment

Tenderers shall make all allowances for plant required (i.e. hoists, cranes, trolleys, etc.) ensuring positioning of the equipment in the UPS room.

33. Photo Voltaic Systems

33.1 Photovoltaic Modules

33.1.1 Overview

Photovoltaic (PV) modules to be either monocrystaline silicon or polycrystaline silicon as specified.

All PV panels to be sourced from a Tier 1 Manufacturer or locally assembled module if Tier 1 Manufacturer components are used..

The panels are to be designed for a minimum life span of 25 years and suitable for hail environmental conditions.

The panels are to have an aluminium frame, polymer backsheet, anti-reflective tempered glass (high impact and thermal shock resistant) cover.

Each cell to have a junction box complete with AC terminal and DC blocking diode. DC blocking diode to be easily replaceable.

Aluminium frame to be suitable for easy bracket installation.

33.1.2 Standards

The latest editions and/or amendments of the following Standards and Codes of Practice are applicable :

a) IEC 61215 Ed.2 – Crystalline silicon terrestrial photovoltaic (PV) module – Design qualification and type approval.

b) IEC 61646 Ed.2 – Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval.

c) IEC 61730-1 Ed. 1.2 – Photovoltaic (PV) module safety qualification - Part 1: Requirements for construction.

d) IEC 61730-2 Ed. 1.0 – Photovoltaic (PV) module safety qualification - Part 2: Requirements for testing.

e) IEC 61701 Ed. 2 – Salt mist corrosion testing of photovoltaic (PV) modules.

f) IEC 62716 Ed. 1 – Photovoltaic (PV) modules – Ammonia corrosion testing.

g) IEC 60904-1 – Photovoltaic devices – Part 1: Measurements of photovoltaic current voltage characteristics.

h) IEC 60904-2 – Photovoltaic devices – Part 2: Requirements for reference solar cells.

i) IEC 60904-3 – Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data.

j) IEC 60904-6 – Photovoltaic devices – Part 6: Requirements for reference solar modules.

k) IEC 60904-7 – Photovoltaic devices – Part 7: Computation of spectral mismatch error introduced in the testing of a photovoltaic device.

l) IEC 60904-9 – Photovoltaic devices – Part 9: Solar Simulator performance requirements.

m) IEC 60904-10 – Photovoltaic devices – Part 10: Methods of linearity measurements.

n) IEC 61853 – Performance testing and energy rating of terrestrial photovoltaic (PV) modules.

o) IEC 60068-2-78 – Environmental testing – Part 2-78: Tests – Test Cab: Damp heat steady state.

p) IEC 60068-2-21 – Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices.

33.1.3 Specific Requirements

a) The PV modules are to achieve the specified levels of performance listed below for the required design life of 25 years under the prevailing site environmental conditions.

Power output during first year of operation	>97%
Power output after 10 years of operation	>90%
Power output after 25 years of operation	>80%

b) The modules are to be arranged to minimize the losses due to mismatching. Where the manufacturer's module data shows an Imp deviation of more than 3%, PV modules shall be sorted into groups to meet a set tolerance. Only modules from the same set shall be used in the same string.

c) The module rated peak power shall be used to determine the peak power of the Plant. The peak power shall be the sum of the manufacturer's name plate data sheets for each individual module.

d) The modules shall be capable of handling a system voltage of 1 000 V.

e) The electrical performance of the PV modules to be rated at "Standard Test Condition" (STC)

f) The fill factor (FF) of the modules to be provided at tender.

g) The efficiency of the PV modules is to be greater than 16%

h) The minimum panel rating shall be 250 W peak.

i) The maximum DC voltage per array of modules is 600V

33.2 Inverters

33.2.1 Overview

Inverters to be suitable for "off grid" or "grid tied", "off grid and battery charging" (Hybrid) or as specified.

The inverter is to be at least IP 65 rating suitable for use in harsh environment with high/low temperatures and high humidity for outdoor installation and IP54 for indoor use.

Inverters to be high efficiency with internal monitoring to ensure maximum PV panel efficiency during the various atmospheric conditions such as Maximum Power Point Tracker (MPPT).

The inverter must be fitted with the necessary surge protection, communication modules and easy connection of DC and AC cabling.

The inverter is to have no moving parts such as fans etc.

The inverter is to have easy mounting arrangements.

33.2.2 Standards

a) NRS-097-2-1: Grid interconnection of embedded generators.

b) NRS-048: Electricity Supply – Quality of supply, Part 2

c) IEC 62093 Ed. 1.0: Balance-of-system components for photovoltaic systems – Design qualification natural environments

d) IEC 62109-1 Ed. 1.0: Safety of power converters for use in photovoltaic power systems – Part 1: General requirements

e) IEC 62109-2 Ed. 2.0: Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters

f) IEC 62116 Ed. 2.0: Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures

g) IEC 60730-1 Ed. 5: Automatic electrical controls – Part 1: General requirements

h) NRS 097-2-1 Ed. 1: Grid interconnection of Embedded Generation Part 2: Small-scale embedded generation

i) IEC 61683: Photovoltaic systems – Power conditioners – Procedure for measuring efficiency

j) IEC 61000 – 6 / 3: Electromagnetic compatibility (EMC)

k) IEC 61727 Ed. 3: Photovoltaic (PV) systems – Characteristics of the utility interface

33.2.3 Specific Requirements

a) The inverter arrangement for the PV Facility that is selected to give overall optimal energy yield from the PV facility over the life of the Project, taking into account the site conditions and the proposed module layouts, shading and orientations.

b) Apart from the detailed technical specifications given in the table below, inverters shall meet the following general requirements.

i) The same type of inverters from the same manufacturer shall be deployed over the whole project with standardized sizes.

ii) Inverters shall be equipped with TCP/TP Ethernet communication capabilities, all inverters shall be able to be controlled / supervised by the same software.

iii) Inverters shall be selected with respect to the local climatic and environmental conditions.

iv) Inverters to be used shall be reliable inverters with a proven track record in the market and reference projects.

v) Inverters have to comply with applicable norms and standards including but not limited to NRS-097-2-1:2010.

vi) Inverters shall comply with South African Grid Code requirements for renewables.

c) Calculations to ensure electrical compatibility between the inverters and the modules selected including, selection of appropriate inverter dimensioning factor and ensuring system voltages lie within acceptable MPPT ranges across the ranges of operating conditions for the sile and for the long term operation of the project are required.

d) PV array from different orientations shall not be connected together to the same MPPT input of the inverter.

e) Inverters to have the following minimum requirements;

Inverters to be suitable string arrangements

Maximum Power Loading	80% calculated using module kW peak
Maximum conversion efficiency	>97%
Maximum Power Rating of Temperature	>25%
Operating temperature (without derating)	-10°C to 50°C
Maximum DC voltage	1000 V DC
A/C connection	1 or 3 phase as specified
Frequency	50 Hz
Total current harmonic distortion	<3%
Protection Rating	IP65 or better outdoor IP54 indoor
Multiple MPPT functionality	
String failure detection	
Continuous data logging	

33.3 AC Cabling

33.3.1 PVC-Insulated Cables

PVC-insulated cables shall be manufactured in accordance with SANS 150.

PVC cable glands shall be made of a barrel carrying a cone bush screwed into one end and a nickel-plated brass nipple and galvanised steel lock-nut on the other end.

Flameproof glands shall comply with SANS 808 Groups 1, 2 (a) and 2 (b).

All cable ends shall be terminated with approved glands ensuring a watertight connection between the sheath, gland and equipment. In cases where copper ECC earth conductors are jointed to the armouring, special glands adhering to SANS 150-1970 par. 5.8.3 (c) shall be used for ECC cables.

The glands to be used shall be constructed so that the armouring of the cable is clamped between two bevelled cores with a screw-clamp, with the cable gland screwed to the gland plate or equipment and fixed with a locknut.

A neoprene or PVC shroud of the correct size shall be used to seal the gland and sheath watertight.

Cable end shall be supplied with the necessary earth connection.

A supporting channel or other approved means of support shall be provided to remove mechanical stress from the cable glands.

33.3.2 XLPE Cables

XLPE isolated cables shall be manufactured in accordance with SANS 1339 Table A.

Cable ends shall be terminated strictly in accordance with manufacturer's specifications. The termination shall withstand the same test voltage as the rest of the cable.

Termination for XLPE cables must have a satisfactory stress relief in order to keep the partial discharges extinguished.

Outdoor termination must be able to withstand air pollution and bad weather without any signs of surface current tracking.

Taped or prefabrication terminations may be used, in accordance with the manufacturer's recommendation.

33.3.3 Cable Installation

The storage, transportation, handling and laying of cables shall be according to first-class practice, with adequate and suitable equipment and labour to ensure that no damage is done to the cables during such operations.

All possible care shall be exercised in off-loading cables on site. Any drums which show signs of damage or mishandling, shall not be used and must be replaced with fresh stocks.

Cable drums shall be removed from site and disposed of.

Where cables have to be drawn around corners, skid plates shall be used for this purpose, and these plates shall be well lubricated. The skid plates shall be securely fixed between rollers and shall be constantly examined during cable-laying operations.

Cables shall be visually inspected for damage during and after laying.

L.V. cables (except where more than one run in a pipe) shall be spaced at least 150 mm apart. Two pilot cables can be run next to each other but must be
600 mm from the nearest 11 kV cable. Cables may not be buried or laid on top of each other.

Cable pipes must maintain or exceed the specified cable spacings. Where additional pipes or cable protection materials are required to be laid.
All cables are to be labelled at each end and at every change in direction or position within a group of cables. Cables are to be labeled at both sides of horizontal or vertical penetrations through structure or building fabric.

Whenever cables enter building, or are exposed for any reason, the exposed portion shall be suitably protected by means of concrete slabs or suitable pipes or ducts, which shall be galvanised if of steel construction.

Testing of Cables

Low tension cables shall be tested to earth and between phases, with a 500 Volt “Megger” test set.

11 kV cabling shall be as follows :

	500 V Megger between phases	500 V Megger between phases and SWA/copper tape	Pressure Test sheath to 4 kV DC between armouring and mass of earth for 1 minute	Pressure Test Phase to phase at 12 kV DC for 10 minutes
Cable drum arrival on site	X	X	-	-
After cable installed and before ends prepared	X	X	X	-
After ends are prepared, before bolting to equipment	X	X	-	X

33.4. DC Cabling

DC cabling provides the electrical connection between individual modules of a solar generation facility to the string combiner boxes and as well as from PV sub-array combiner boxes to inverter. Number of combiner boxes between string and connection to inverter shall be defined to achieve optimum output and allow suitable access for O&M purposes.

The DC cable losses shall not exceed 1% except where otherwise agreed with the Employer. A detailed wiring loss calculation shall be submitted as part of the design submission.

DC string, array and main cabling must be selected and installed in such a way to prevent he risk of leakage currents. Single core conductors shall be used for the enforcement of cable protection against outer impact.

The area inside DC cable loops shall be kept as small as possible to reduce the induction of unwanted voltages and currents, for example due to lightning strikes.

Insulation and resistance measurements shall be carried out after every cable installation In order to locate any possible faults and records kept so that faults can be identified in future.

Modules connectors and DC cable connectors shall be compatible and from the same manufacturer throughout the whole PV plant.

Cable connectors shall be contact-proof and corrosion proof.

33.4.1 DC Cables Specific Requirement

1.1	Double insulated, fire rated, black outer sheath and Red/Black inner	
1.2	Cable Couplers to be MC4 type	
1.3	Waterproof and UV resistant	
1.4	IP Protection (IEC 60529) outdoor installation	≥ IP 65
1.5	Maximum AC Voltage	1 800 V
1.6	Maximum ambient temperature	85°C

Cable be continuous without any joints. If a junction is necessary, the correct MC-4. couplers are to be used.

33.5 DC Distribution Board (DC-DB)

The PV distribution board serves as a combiner of several inverter DC output cables to connect the PV system via a single PV main cable.

The DC-DB shall contain the following minimum equipment:

.1 Main switch circuit breaker (4P lockable)
.2 Circuit breaker for each inverter (4P, lockable); and
.3 Overvoltage protection devices

The DC-DB shall be installed alongside the inverters with easy access.

33.6 DC Combiner Box

DC combiner boxes are to combine several string cables in parallel or for extending the string cables that are directly connected to the inverter. DC combiner boxes contain string and array protection devices such as.

.1 Each string shall have DC fuses with string disconnection switch (on-load isolator) on DC-negative and DC-positive or 2P DC circuit breaker.

.2 Surge protection devices

.3 Array disconnect switch on- load isolator.

The DC combiner boxes shall be equipped with sun shields where exposed to direct sunlight to prevent overheating inside the boxes.

The DC combiner must be easily accessible.

The following specific requirements shall be adhered to.

7.1 DC Combiner Box Specific Requirements

.1 Rated for exterior condition and suitable for working environment

.2 Weatherproof and UV resistant

.3 Plus and minus (+ and -) side shall be separated within the box

.4 DC fuses for each string with on-load isolator switch or DC circuit breaker

.5 Surge protection devices to be provided

.6 Array on-load isolation switch required

.7 IP Protection (IEC 60529) to be IP 65 or greater

.8 Safety Class II

.9 Rated for Continuous DC Voltage of 1 000 V

33.8. DC and AC Isolation

A DC rated on-load isolators should be provided on the DC side of each inverter and AC rated on-load isolator on the AC side of each inverter. This is required to totally isolate the inverter for maintenance and repair/replacement.

The DC and AC on-load isolator shall be located next to the respective inverter.

The isolators shall be padlockable and numbered/labelled correctly.

If a DC isolator is included in the DC combiner box, located in close proximity to the inverter, another DC isolator is not required.

33.9. Earthing

The total earthing system of any electrical installation shall be in accordance with SANS 10142. Earth conductors shall be stranded copper with green PVC insulation installed on a radial arrangement from each distribution board, with no T joints or interconnection of circuits.

The earthing system to be in accordance with Solar PV industry best practice and in compliance with SANS 10200:1985 and SANS 10292:2001.

Earthing tests to be conducted on the earthing system to fully verify the safety of the site.

33.10. Bonding

All metallic services to be cross bonded in the vicinity of electrical equipment and circuiting including hot and cold water pipes, waste and drain pipes, ceiling grids, cable trays, hand rails etc. The earth loop impedance to the furtherest point from local distribution board of all metallic services shall be within acceptable limits.

All steel pipes shall be connected with solid 12mm x 0.8mm perforated or solid copper strapping to the nearest distribution board. The strapping shall be fixed to the pipe work with brass nuts and bolts and against walls with brass screws at 150mm centres.

In all cases where steel pipes are positioned within 1.5m of distribution boards, an earth connection consisting of copper strapping shall be installed between the pipe work and the board. In vertical building ducts accommodating steel pipes and electrical cables, all pipes shall be earthed at each distribution board.

PV modules are to be bonded via PVC insulated earth wire if the mounting system does not provide an acceptable earthing of the PV module frame.

PV module mounting systems are to be bonded to the AC system earth bar.

33.11. Lightning Protection

The building's existing lightning protection system is to be determined.

Should lightning protection be required the lightning protection system shall be installed in accordance with the latest SANS/IEC 62305 standards.

The lightning protection system shall protect the building against damage caused by lightning strikes. The system lightning protection shall be independent and discharge to ground via earthing elecrtrodes.

33.12. Surge Protection

Overvoltage protection shall be installed at DC side as well as AC side of the inverter and within the PV arrays.

The design and equipment shall be according to the following requirements.

12.1 Overvoltage/Surge Protection Devices Specific Requirements

.1 Distribution (AC Distribution Boards)

Overvoltage arrestors (SPD Type II) limited surge voltage: 4 kV at 10 kA (8/20 µs)

.2 Control and Monitoring System (CMS)

Overvoltage arrestors (SPD Type II) limited surge voltage : 2.5 respectively 15 kV

.3 DC Distribution / DC Combiner Boxes

Lightning current arrestors (SPD Type I or combination of Type I and Type II), peak current: 50 kA (10/350 µs), limited surge voltage: 4 kV at 25 kA (8/20 µs)

In general, the design of the DC system must ensure that cables are kept in parallel and as short as possible, while cable loops are also avoided or restricted. Protection against direct strikes (direct strike lightning protection) shall be installed and coupling as a result of strikes elsewhere in the grid (indirect strike lightning protection) shall be taken into consideration and designed out of the system.

33.13. Metering

An energy metering panel to be installed inside the AC Distribution Board or a separate indoor metering kiosk

The metering solution includes, but not limited to CTs. VTs and CT and VT test blocks.

The energy meter shall provide tariff metering, bi-directional energy measurements and power quality monitoring. The power monitoring quality and assessment shall be as described in Section 9 of Renewables Grid Code Ver. 2.6, NRS048-2 and SANS 61000.

For approved energy meters without power quality monitoring capability, a separate power quality monitoring meter shall be provided that meet the minimum power quality requirement in Section 9 of Renewable Grid Code Ver. 2.6 NRS048-2and SANS 61000 and shall be installed in the panel with the energy meter.
The energy meter and power quality meter shall communicate with the respective control and instrumentation devices. The minimum communication protocol is Modbus RS485 and TCP/IP Ethernet.

33.14. Monitoring

14.1 Overview

An on site supervisory control and monitoring system (CMS) for the PV plant that is responsible for data acquisition and monitoring of instruments and data acquisition as follows.

14.2 Control and Monitoring System (CMS) Server

General Requirements

The CMS server includes, as a minimum;

.1 A central processing unit (CPU)
.2 A 19” (inch) free standing liquid crystal display (LCD) monitor with a HDMI, display port, VGA or DVI connectivity; and
.3 keyboard and mouse with USB or PS2 connectivity

The characteristics of the CPU include, as a minimum:

.1 A tower type or a 19” (inch) rack-mountable type enclosure
.2 An on board historian database to continuously save real time plant data for the lifespan of the plant

.3 Microsoft 7 operating system
.4 Removal media such as a digital versatile disk (DVD) writer or Blu-Ray disc writer and front accessible universal serial bus (USB) port
.5 rated for 24/7 operation

The CMS server shall accomplish multiple functions that include, as a minimum;

.1 Hosting the required software for all applications and the anti-virus
.2 Comprehensive operating and monitoring functionality of the plant in real time
.3 Network configuration, logic development, mimic development, antivirus software and software updates
.4 Continuous storage of real time plant data on to the CPU's historian database
.5 an OPC-DA and OPC XML protocol to communicate between multi-vendor systems and to remotely transmit plant real time data to the PDS in MWP via Ekom's corporate network
.6 A web application that shall make available, multiple pages of mimics of real time plant data for monitoring and alarming to authorised remote clients connected to the Eskom network
.7 Automatic copying of data from the CPU's built-in historian on to the removable media at pre-configured intervals
.8 Saving of information, backing of data onto removable media, closing all running applications and shutting down the CPU in an automatic controlled sequence after detecting the loss of the input power to the UPS system.

33.15. AC LV Switchboards

33.15.1 Standards Requirements

Low Voltage Switchgear and Control Gear Assemblies, are to be manufactured in accordance with SANS 1473–1 (as amended), SANS IEC 60439-1 (as amended) and SANS 10142-1 (as amended) specifications.

With regard to the above specification the following applies to the manufacture of the distribution boards.

33.15.2 Board Construction and Design

a) Floor standing multi cubicle type assembly/unless otherwise specified

b) Stationary indoor installation

c) IP54 unless otherwise specified

d) Form 2b unless otherwise specified (Terminals in cable chamber for outgoing conductors, per functional unit, to be individually shrouded with 5 mm thick transparent polycarbonate cover)

e) Naturally ventilated

33.15.3 Electrical Characteristics

a)	Operational Voltage	400 Volts phase to phase 230 Volts phase to neutral/earth
b)	Insulation Voltage	1000 Volts phase to phase 600 Volts phase to earth
c)	Impulse Withstand Voltage	500 Volts phase to phase

d) Rated short time withstand current (fault level) as shown on the single line diagrams

e) Rated peak withstand current is to be in accordance with table 5 in SANS IEC 60439-1.

f) Cross sectional area of protective conductors with regard to thermal stresses due to current of short duration are to be based on a duration of 0.1 seconds.

g) Earthing system : TN-S

Note: Rated currents of circuits and electrical equipment as shown on the drawings DO NOT take into account the derating of such circuits and electrical equipment due to temperature rise.

33.15.4 Environmental Conditions

b) Maximum air temperature (at any point) within the distribution board is not to exceed 10°C above ambient of 40°C maximum and an average of 35°C over a 24 hour period.

Note: Should the heat rise within the distribution board exceed the above limits due to the limitations of the room size etc. supplierss are to advise the anticipated heat rise in each cubicle.

b) Relative humidity – As per clause 6.12.1 in SANS IEC 60439-1.

c) Pollution degree 3 applies

e) Installed at sea level/inland as applicable

33.15.5 General

The following general requirements are to be complied with provided they do not conflict with the above requirements.

33.15.5.1 Enclosures

Enclosures for distribution boards and control panels shall be wall or floor mounting as indicated, shall be engineered to accommodate the necessary equipment specified and to comply with this specification.

The minimum thickness of the chassis and partition metal work shall be 1,5 mm for assemblies not exceeding 0,75 m² or 2 mm for larger panels. Thicker sheets shall be used for very large panels and where the weight of the equipment would cause buckling or vibration.

Lap welding of panels and boxing of sections, is unacceptable unless specifically approved. Bolted stiffening channels and braces are acceptable.

Completed sheet metal enclosures shall be free, internally and externally, from burrs, sharp edges and blemishes. A removable steel base frame shall be allowed for floor mounting boards. Removable lifting eyes shall be provided for heavy panels.

All switchboard covers/doors are to be of the hinged type. Covers which have to be lifted out of position are unacceptable.

Switchboards are to be extendable in both directions.

Unless otherwise specified, all wall mounting boards shall be front access only, and shall be manufactured in two parts :

a) a rear chassis, either built into or attached to, the supporting wall;

b) an outer panel, secured to the chassis on completion of the work, and readily removable from it.

The chassis will be manufactured from zinc coated mild steel, zintex steel, other approved method of electro galvanised mild steel or 3 CR12. The chassis shall have suitable knockouts, along the top and bottom panels, for the terminations of all conduits, in not more than two rows. A feeder cable entry knockout shall also be provided, suitable for the feeder cable rating indicated on the drawings.

The outer panel, secured to the chassis by means of adjustable bolts, carrying the equipment trays, the busbars and the wiring harness, is to be securely supported.

33.15.5.2 Painting

The surface is to be prepared prior to painting by phosphatisation cleaning/degreasing treatment. The surface is then to be coated with an etching primer, followed by a base coat and an epoxy polyester powder coating to a minimum thickness of 110 µm.

The colour of the finishing coats shall be decided at the time of shop and installation drawing approval.

Any on site paint damage to be treated and touched up immediately.

33.15.5.3 Accessories

Hinges shall be of the brass lift off type. Door/cubicle catches shall be of the Barker Nelson type provided these meet the standard specification. Rear covers to be hinged and locked by electrical panel key and shall not be secured by screws or bolts. Weld-on type hinges and door locks will not be acceptable.

Door opening, closing, latching and de-latching operations shall be smooth and quick, whilst ensuring proper compression of the sealing gaskets without damaging or marking the paintwork or corrosion-resistant surface of the Board.

Sealing strips and gaskets shall be made of durable, non-hardening synthetic rubber or other suitable material. Care must be taken to ensure that even pressure is exerted along the entire length of the gasket, and that neither deflection nor buckling of panels occurs when the gasket is compressed.

For switchboards intended for use indoors, and for external use in areas remote from the coast (100 kms), bolts, nuts and washers shall be cadmium-plated, electro-plated or galvanised.

For switchboards intended for use outdoors or in coastal areas e.g. Durban area, the minimum corrosion specification for all nuts, bolts and washers shall be 316 L stainless steel. Busbar bolts must be high tensile steel type, complete with lock-nuts and lock washers. To avoid damage to the paintwork, screws, bolts, door locks, etc., must not be in direct contact with painted surfaces.

The use of self-tapping screws is unacceptable. All tapped holes in metalwork shall have a minimum tapped thread length equal to the diameter of the tapped hole. All concealed/inaccessible nuts are to be of the permanently captive type. The electrogalvanised caged nut is unacceptable.

Tapped holes shall have the exposed metalwork protected against corrosion by the application of a suitable inhibitor over the tapped area, such as Tectyl or copperslip.

33.15.5.4 Cabling, Wiring and Busbars

The main busbars (including the neutral) shall be installed together along the top (wherever possible) of the switchboard, and along its full length. Busbars connected to C.B. stubs are to be sized and connected in accordance with the C.B. manufacturer's requirements.

All outgoing circuit breakers on main switchboards shall be connected to vertical busbar droppers with copper busbar tails. Busbar tails to be shrouded.

Busbar droppers from the main busbars to be segregated from cable chamber.

All outgoing circuit breakers on main switchboards shall be fitted with copper busbar tails to facilitate cable terminations in the cable chamber and not on the circuit breaker. Busbar tails shall be shrouded.

Spare spaces shall be fitted with copper busbar tails (load and supply side) for future connection.

Phase identification shall be Red, White, Blue, reading top to bottom, left to right, and from front to back, when facing the front face of the board.

The insulation of the busbars and conductors shall not be stripped beyond the leading edge of the connection /terminal in which it has to be accommodated. Stripping shall be carried out without damage to the conductor, by means of a cable stripper.

Crimping lugs and ferrules shall be used for connection into equipment not provided with screw-type compression terminals. All crimps of conductors 35 mm^2 and above are to be subjected to test crimps.

All wiring and terminations shall be readily accessible. Under no circumstances may terminal rails be fixed to the D.B. tray or the side panels of the D.B. tray or the side panels of the D.B., or located close to live terminals, or positioned behind wiring run to equipment in the board.

The wiring shall be carried out neatly, along perpendicular lines, and it shall be accommodated in enclosed wiring channels.

The wiring shall not preclude the removal of, nor block the access to, any component.

Insulated conductors shall not be bunched together in order to avoid heat accumulation within the core of the bunch. If bunching of conductors in unavoidable, the conductors should be de-rated in accordance with the relevant Table of the S.A.N.S. 10142 as amended, Code of Practice

Sub-distribution circuits protected by HRC fuses need only be rated for the maximum prospective asymmetrical fault level possible when the largest fusible link is installed in the fuse base.

The minimum conductor area of any wiring shall not be less than 2,5 mm^2 and no hard drawn copper wiring is to be used within the board. All wiring is to be of the tinned, fine stranded flexible type.

All wiring within boards is to be insulated. No B.C. wiring is permitted for either phase neutral or earth wiring; the earth bar being the exception. Single phase distribution boards shall be wired in red and black PVC insulated conductors. Three phase distribution boards shall be wired in red, white and blue, black and green PVC insulated conductors.

Control panels and motor contactor boards shall be wired on the power side, with red, white and blue insulated conductors. Live control wiring shall be orange. Unearthed and DC control wiring shall be grey.

Neutral connections shall be black, this colour must not be used for any other connection. Earth wiring shall be insulated green, or striped green-yellow, conductors.

33.15.5.5 General and Installation Arrangement Details

Large air circuit breakers and switch fuse units shall not be positioned at high level, unless facilities are provided to assist maintenance staff in withdrawing these units.

The arrangement shall be such that sufficient space exists between adjacent items of equipment for the installation of incoming and outgoing conductors and for heat dissipation.

Moulded case circuit breakers in main switchboards shall be mounted side on.

The Board shall be of sufficient dimension to allow the installation of all equipment specified and any future equipment indicated on the drawings, without unduly restricting the access to, and the clearance between, the various rows.

Particular attention shall be paid to the accommodation and bending of incoming and outgoing conductors within the enclosure, and the working space necessary for making off the cables, installing the lugs and connecting into the equipment. Suitable provision shall be made for vermin-proofing the cable entries and earthing the armouring. Busbar bending radii shall not be less than the minimum permissible for the thickness of busbar being used.

Control/metering fuses or circuit breakers shall be base mounted on the relevant busbar. Unprotected wiring may not be run off busbars or from C.B. power terminals to remote fuses/equipment. These fuses/circuit breakers shall be easily accessible and completely safe for maintenance staff to service and repair.

Ring type current transformers shall be insulated from the busbars and fixings making electrical contact with the bar must be total shrouded and locked into position with lock nuts. Current transformers around different phase may not touch each other. A minimum clearance of 50 mm is to be maintained between adjacent CT’s, and between CT's and adjacent busbars.

In general, main switchboards shall be arranged such that it is possible to make off and terminate cables and install additional switches, without any risk of coming into contact with live conductors.

Main switchboard panels shall be of uniform width, with not more than two size variations, i.e. 600 mm and 750 mm.

Single phase sections of three phase boards shall be separated from each other. Lighting on the left-hand side and single phase power circuit on the right-hand side or lower section or top section. Three phase power circuits are to be grouped together and be remote from the above single phase circuits. Extra space for future circuits shall be allowed for, as specified. Covers are to be provided over spare spaces. Similar provision for future circuits shall be made on the busbars, neutral and earth bars.

All parts of the distribution board metalwork shall be electrically continuous, and a suitable stud shall be provided for the earthing of the enclosures.

Particular attention shall be paid to the earth continuity of removable and hinged access panels, particularly those carrying supervisory and control equipment.

flexible copper straps may be used for the purpose of ensuring the earth continuity between the board and the panels.

A removable facia cover shall be provided behind a hinged door through which toggles and other operating handles shall project and fixed by means of suitable fasteners. This plate shall be supported so that its replacement and removal is easily achieved without having to manoeuvre the plate so that fasteners can engage.

All wiring terminations and connections shall be made behind the facia plate and shall not be accessible without its prior removal. The board shall be designed so that the switch toggles, instruments, etc., are easily accessible to operators of average height, (i.e. upper edge of equipment shall not be higher than 2 m or lower than 0,25 m above floor level) unless otherwise specified.

LV main and sub-distribution boards and motor control panels shall be erected, installed and commissioned in the positions shown on the drawings.

During transport to site and installation, the boards shall be protected against mechanical damage and vibration.

Boards shall not be moved on to site, nor be installed, until all building services and finishing trade work has been completed in the room or vicinity of where the boards are to be installed. If boards are installed prior to this the entire unit in each case must be shrouded in PVC bubble type wrapper.

The boards shall be installed in such a manner as to facilitate extensions, maintenance, testing and repair work, with easy access to cable entries/terminations, current transformers, potential transformers, small wiring terminal boards and relays, and busbar connections.

33.15.5.6 Installation/Shop Drawings and Samples

As a minimum, the shop drawings shall indicate:

a) Busbar and dropper bracing and support details, including actual or type test certificate from an accepted testing station, in substantiation of short circuit capacity and withstand capability of the system.

h) Temperature rise calculation for each cubicle based on all circuits are equipment (including space for future) to be installed in the cubicle.

i) Main and distribution busbar section and size including selection/sizing criteria and calculations in substantiation of the full load rating (including derating for temperature rise limits and sizes/connection details to circuit breakers).

j) Equipment selection to achieve full load rating requirements shown on drawings to accommodate derating for temperature rise.

k) Time current characteristics of the incoming and outgoing circuit breakers and switch fuse units on transparent drawing paper to facilitate super position of the characteristics on one another.

l) Fully dimensioned and detailed equipment layout/front elevation and sectional side elevations.

m) Details of construction, compliance with IP rating, access and cable termination facilities etc.

As a minimum, the dimensioned installation drawings shall indicate:

h) Position of switchboard relative to cable trenches, cable trays, adjacent wall and equipment.

i) Surrounding clear space between walls and adjacent equipment for access and maintenance purposes.

j) Cable entry details and cable routing and crossover aspects when entering the board.

k) Details of supports across trenches and the interface between the cable trench covers and switchboard.

The record drawings and manuals shall comprise the relevant final as approved and installed installation and shop drawings. The maintenance and fault finding manuals shall be explicit, shall cross-reference to the drawings, schematics and control logic diagrams, and shall provide full maintenance details, requirements, methods and schedules for each and every type of device employed. Furthermore, the manual shall contain spare parts lists and numbers, for all equipment.

33.15.5.7 Labelling

All labels are to be of the traffolite type and fixed to the board with nuts and bolts. All internal control and indication components are to be labelled and correspond to the as built drawings.

33.15.5.8 Trench Boxes

Wherever necessary, cable trench covers must be cut to size and replaced to fit snugly around floor standing boards.

33.16. Structural and Civil Requirements

33.16.1 Overview

The PV modules mounting system to be suitable for the building roof. This is to include fixing brackets, waterproofing, wind loading, penetrations etc.

A registered Structural Engineer to provide the design details and to sign off the installation on completion.

Before manufacture the design by the Structural Engineer must include drawings, installation methodology, waterproofing details and corrosion protection methods.

All concrete plinths, wall penetrations, holding down bracket, trenching, saw cutting tarmac / concrete, backfilling required.

33.16.2 Standards

a) All civil engineering construction work shall comply with the requirements of SANS 1200: Standard Specification for Civil Engineering Construction.

b) All steel materials supplied and erection of the steel work shall comply with the requirements of SANS 2001 – CS1: 2012 Ed. 1.01 – Construction Works CS1 – Structural Steel Works.

c) SANS 2001 – Construction Works – Part CC1 – Concrete Works (Structural)

d) For surface treatment of steelwork - SANS 121: 2011 – Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods and SANS 1200HC: 1988 – Standardized specification for civil engineering construction Section HC: Corrosion protection of structural steelwork.

e) All buildings shall comply with the requirements of SANS 10400: National Building Regulations.

f) All building work shall comply with the requirement of the Model Preamble for Trades (1997) as issued by the Association of South African Quantity Surveyors.

33.17. Cable Trays and Ladders

33.17.1 General

Cable trays and ladders shall comply with SANS 763 with respect to finishes.

Cable trays and/or ladders to include the necessary supports, clamps, hangers, fixing materials, bends, angles, junctions, reducers, T-pieces, etc.

33.17.2 Supports

Trays shall be supported at the following *maximum intervals*:

1.6mm Thick metal trayswith 12mm return	1000mm
Metal trays with folded overreturn and 50mm upstand	1220mm
2.4mm Thick metal trays and 75mm return	1500mm
Metal cable ladders other than those mentioned below	1500mm
3.0mm Thick PVC trays with 40mm return	1000mm
4.0mm Thick PVC trays with 60mm return	1500mm

In addition, trays and ladders shall be supported at each bend, offset and T-junction. The above spacing of supports is applicable to both vertical and horizontal installation of trays and ladders.

33.17.3 Joints

Joints shall be smooth without projections or rough edges that may damage the cables. . Where joints do not coincide with supports, joint shall, in the case of trays with single returns, be made by means of wrap-around pieces of the same thickness of the tray and at least 450mm long. The two cable tray ends shall butt tightly at the centre of the splice and the splice shall be bolted to each cable tray by means of at least eight round head bolts, nuts and washers. Splices shall have the same finish as the rest of the tray. Where joints which do not coincide with supports occur in trays with folded over returns, tight fitting metal guide pieces, at least 450mm long, shall be inserted in the folded return to provide the necessary support to the two cable tray ends. Splices as described above shall be provided at joints, which do coincide with supports if the loaded tray sags adjacent to the joint due to the interruption of the bending moment in the tray.

33.17.4 Fixing

Trays and cable ladders shall be bolted to supports by at least two round head bolts per support. Bolts shall be securely tightened against the tray surface to avoid projections, which might damage cables during installation.

33.17.5 Fixing to the Structure

The support for cable trays and ladders shall in all cases be securely fixed to the structure by means of heavy duty, expansion-type anchor bolts. Cantilevered trays shall be supported at two points with a minimum of two expansion bolts per support. The fixing shall take into account site conditions that prevail during installation.

33.17.6 Earthing

Metal trays and ladders shall be bonded to the earth bar of the switchboard to which the cables are connected with a Cu PVC cable. Bare copper stranded conductors or copper tape shall be bolted to the tray or ladder to ensure electrical continuity. These shall be installed on the outside of the tray to ensure they are visible and are not damaged by cable installation.

33.17.7 Expansion Joints

Where cable trays/ladders have to cross expansion joints, the trays/ladders must form a gap of at least 25mm between the two sections. Cables installed across expansion joints, must have enough slack to accommodate the expansion of the building.

33.18. Conduit and Wiring Channels

Unless otherwise specified, all conduit is to be concealed by casting/building into walls and slabs, or by running in ceiling spaces and within purlins.

Conduit runs to wall luminaire outlets shall, in all instances, be from above the outlet and not below via floor slabs. No conduit is permitted in ground slabs, unless otherwise indicated on the drawings, or required by building construction techniques and sequences. Luminaire conduit shall be looped from outlet to outlet, and no additional drawbox positions will be permitted.

No more than two right-angled bends between draw boxes is permitted.

All 150 x 50, 150 x 150, or larger, terminal conduit boxes shall be of galvanised steel type. The corresponding PVC type will not be accepted. PVC round conduit boxes that have covers fixed by screwing directly into the PVC box, are unacceptable.

In coastal areas (within 70 kms of the coastline) all galvanised sheet steel outlet boxes are to be given two coats of Red Lead or Glyptal Primer, before installation.

Conduit shall only be run parallel or at right angles to outside walls when run in ceiling spaces, unless otherwise indicated on drawings.

Exposed metal conduit threads are to be protected against corrosion.

Black enamelled steel conduit may not be used in coastal areas. All steel conduit systems must be electrically continuous. PVC conduit systems are to be provided with an earth wire for each circuit.

All draw trays shall be sheet steel galvanised and painted as above, or as specified.

Conduits across expansion joints shall be arranged in such a manner that each side of the joint is free to move relative to the other, without damage to conduit or wiring.

Unless otherwise indicated, only one circuit is to be installed in each conduit. This does not apply to conduits rising from distribution draw trays. In this case the conductors to be derated by 50% (fifty per centum) and ensure that conduit trunking capacity is adequate to provide 50% (fifty per centum) (maximum) occupancy.

A maximum of two 90° bends or the equivalent displacement will be allowed between outlets and/or boxes.

Care shall be taken to prevent debris or moisture entering conduits during and after installation. Conduit ends shall be sealed by means of a solid plug, which shall be screwed to the conduit end. Conduits shall be cleaned and swabbed to remove oil, moisture or other debris that may be present before conductors are installed. Swabs shall not be attached to the conductors.

33.18.1 Termination of Conduits

a) Switchboards, Power skirting, etc.

Conduits shall be terminated by means of a brass female bush and two lock nuts in distribution boards and power skirting, etc. The conduit end shall only project far enough through the hole to accommodate the bush and lock nut.

b) Draw Boxes

A female bush and two lock nuts shall be used to terminate conduits at draw boxes should there be sufficient room in the box. Where there is insufficient room, a coupling and a brass male bush may be used with sufficient allowance for the reduction of the internal diameter by the male bush.

33.18.2 Screws, Bolts and Nuts

Steel locknuts of thick gauge steel with milled sides shall be used in all cases. Cadmium-plated bolts and nuts shall be used, except where the installation is exposed to the weather, in which case brass bolts and nuts shall be used. Screws shall be installed in all tapped holes in fittings and accessories to prevent damage to the screw thread by concrete or plaster. The screws shall be screwed down completely to prevent damage to the thread on the screw.

33.18.3 Surface Installation

a) Appearance

All conduits shall be installed horizontally or vertically as determined by the route. Where conduits are to be installed directly alongside doorframes, beams, etc., that are not true, the conduits shall be installed parallel to these.

b) Saddles

Conduits shall be firmly secured by means of equidistant spaced saddles. Conduits shall be secured within 150mm before and after each 90□ bend. Saddles shall be fixed by means of screws and plugs and not by means of nails.

c) Joints

Joints will only be allowed in surface conduit lengths exceeding 3500mm.

d) Accessories

Inspection bends or tee pieces shall not be used. Non-inspection type bends may be used in the case of 32mm or 50mm diameter conduits.

All draw boxes supporting light fittings or other equipment shall be fixed independently of the conduit installation.

e) Offsets

Where an offset is required at conduit terminations or cross-overs, the conduit shall be saddled at the offset.

f) Cross-overs

Conduit routes shall be carefully planned to avoid cross-overs. Where a cross-over is unavoidable, one conduit only shall be offset to cross the other. Alternatively, cross-overs shall be installed in purpose-made boxes.

g) Parallel Conduit Runs

Parallel conduit runs shall be equidistantly spaced and saddles shall be installed in line. Alternatively, a special clamp can be used to secure all conduits together.

h) Painting of Conduits

All surface mounted conduits and accessories shall be painted with high quality enamel paint or as otherwise specified. The colour shall comply with the colour code specified for the installation, or where no code has been specified, shall match the colour of the surrounding finishes.

33.18.4 Expansion Joints

Where conduits cross expansion joints in the structure, approved type draw boxes, which provide a flexible connection in the conduit installation, shall be provided.

The draw box shall be installed adjacent to the expansion joint of the structure and a conduit sleeve one size larger than that specified for the circuit, shall be provided on the side of the draw box nearest the joint. The one end of the sleeve shall terminate at the edge of the joint and the other shall be secured to the draw box, by means of locknuts and a standard bushed adaptor.

The circuit conduit passing through the sleeve shall be terminated 40mm inside the draw box and in the case of metallic conduit; the conduit end shall be fitted with a brass bush. The gap between the sleeve and the conduit at the joint shall be sealed to prevent ingress of wet cement. In the case of metallic conduit, an earth clip shall be fitted to the conduit projection inside the draw box and the conduit bonded to the box by means of 2.5mm² bare copper earth wire and a brass bolt and nut.

In addition to an earth wire, which may be specified for the circuit, a 2.5mm² bare copper wire shall be provided between the first conduit box on either side of the joint in the case of metallic conduit. The conduit boxes shall be drilled and tapped, and the earth wire shall be bonded to the boxes by means of lugs and brass screws.

Draw boxes and the expansion joint shall be provided with a suitable steel cover plate fixed to the box by means of screws. The cover plates shall be installed before the ceilings are painted.

Where a number of conduits are installed in parallel they shall cross the expansion joints of the structure via a single draw box. A number of draw boxes adjacent to each other will not be allowed.

33.18.5 Wiring Channels

The channels shall be either hot dip galvanised or electro-galvanised, shall be coated with cold galvanising at all joints, sections that have been cut and at places where the galvanising has been damaged. Powder coated ducts shall be touched up at joints, cuts and damaged portions, using paint recommended by the manufacturer of the channels.

a) Cover Plates

Channels up to 125mm wide shall have snap-in cover plates of metal or PVC, whilst channels wider than 125mm shall have metal cover plates fixed in position by screws.

The finish of steel cover plates shall be the same as that of the channels.

b) Accessories

All accessories, i.e., hangers, brackets, etc., shall be purpose-made and in general have the same finish as the channels.

c) Capacities of Channels

Trunking is defined as a channel having one or more sides removable for access to wiring, whilst ducting has no removable sides.

In the case of trunking, the overall cross-sectional areas of all the conductors, including insulation, shall not exceed 45% of the internal cross-sectional area of the trunking whilst in the case of ducting, this figure shall be 40%.

Where trunking or ducting is run in a distribution board, it shall be filled to not more than 30% unless it is ventilated, in which case, the former figures shall apply.

Common wire ways will be permitted only in the case of conductors carrying relatively low currents, namely lighting and single phase socket outlet circuits. In such cases, the maximum number of wires per conduit shall be in accordance with SANS 10142.

d) Fixing of Channels

Channels up to 75 x 75mm shall be supported at maximum intervals of 600mm and larger channels at maximum intervals of 1m. Channel runs shall be carefully planned to avoid clashes with other services and to ensure that all covers can be removed after completion of the entire installation. Purpose-made clamps, hangers etc., shall be used as required

e) Installation in Concrete

Channels shall be filled with polystyrene or other suitable fillers to prevent ingress of cement and shall be securely fixed in position to the shuttering.

f) Joints

Adjoining lengths shall be aligned and securely jointed by means of fishplates fixed by mushroom bolts, washers and nuts or connection pieces that are pop-riveted to both adjoining sections. Adjoining sections shall butt tightly. Covers shall fit tightly across the joint.

Where channels cross expansion joints in the concrete, suitable expansion joints shall be provided in the channels by means of fishplates pop-riveted or screwed to the channel on one side of the expansion joint and floating freely in the channel on the other side of the expansion joint.

g) Support for Conductors

All conductors in inverted cable channels shall be retained by means of metal clips or metal spacer bars at not less than 1m centres. Clamps shall be provided on suitable draw boxes for this purpose.

h) Internal Finishes

Burrs and sharp edges shall be removed and the inside edges of all joints shall be lined with rubber cement or other suitable rubberised or plastic compound to prevent laceration of the conductor insulation.

All holes through which conductors pass shall be fitted with grommets.

i) Vermin Proofing

All wire ways shall be vermin proof after installation. Holes shall be covered by means of screwed metal plugs or by means of metal strips that are bolted or pop-riveted to the channel.

33.19. Service Conditions

33.19.1 Normal Service : As scheduled

33.19.2 Maximum ambient temp. : +40°C

33.19.3 Minimum ambient temp. : -5°C

33.19.4 Humidity : Max. Humidity: 95%

33.19.5 Rain fall : high in summer months, low in winter months.

33.19.6 Atmosphere : Corrosive due to wind blown salt spray

All equipment and materials shall be suitable for the climatic and environmental conditions pertaining to coastal conditions.

Contact between dissimilar metals shall be avoided. As a minimum, the following electrode potentials shall not be exceeded.

a) for connections exposed to the weather, salt water vapour or salt water, 0,25V.

b) for connections of interior parts subjected to condensation but not contaminated by salt, 0.50V.

33.20. Electrical Supply System

33.20.1 Supply Technical Data

System Voltage : 400V ±10% as applicable

Rated Frequency : 50Hz

Phase rotation : 3 phase, RWBR (clockwise)

Design SSCC : 20kA at 11 kV

Earthing System : TNS

34. Services Interface Testing

The requirements as outlined in this section are the minimum requirement to be completed by the contractor to demonstrate correct operation of the systems, and for inclusion in the as built manuals on completion of the project

34.1 Purpose of Services Interface Testing

To ensure the satisfactory and safe operation of the building. To achieve this each service and the interface of all services must be verified to ensure correct operation under all possible conditions that may be encountered during the operation of the building. The only way to check that this will be achieved, is to initially and correctly test each system in detail and then in conjunction with each other.

34.2 Test Co-Ordinator

The Principal Building Contractor (PBC) is contractually responsible for co-ordinating all site activities, and is therefore responsible to plan, organise and program the various sub trades in terms of the site program.

This document is therefore an aide to the PBC and the various sub-contractors involved to ensure that the Client can be satisfied that all systems work individually and collectively under all conditions that will be encountered. Notwithstanding anything to the contrary, the ultimate responsibility for the equipment on site and for on-site safety aspects remains with the PBC and/or the contractors. The sub-contractors must therefore be present to operate the relevant plant and to ensure overloading or stressing does not occur.

34.3 Test Procedure

Each services sub contractor is to provide an overview of their system, a brief description of how the service operates under the various operational conditions (refer to item 1.5).

34.3.1 Individual Services Preliminary Testing

Each service consulting engineer should produce a detailed testing sequence of;

Tests to be carried for the particular service;
How these are to be carried out to ensure compliance with the contract documents and specified conditions;
The testing sequence priority, the required readings and the test equipment to be employed;
The sequence of tests to suit the system/s and the service completion program starting with the control and safety systems;
The required final test report.

The PBC in conjunction with the particular services contractor prepares a suitable testing program.

The protection, control and safety aspects of each service are to be individually tested by service contractor as per the test report completed prior to permanent power being made available for plant start up (i.e. before driven equipment is started up).

Once this is done then each service can be individually tested and commissioned into service in terms of its intended design function.

Once each service has undergone start up and the respective consultants are satisfied that the plants are operating correctly and safely with the safeties and protection in place the usual on going testing, balancing and setting can continue for each service.

34.3.2 Combined Services Preliminary Testing

Each service consulting engineer should produce detailed testing procedure outlining the following:

Tests to be carried out with each service to be interfaced with, for their area of responsibility;
The testing sequence, required reading and test equipment to be employed;
The required final test reports.

The PBC in conjunction with the particular services contractor prepares a suitable testing program.

Once this is achieved the interfacing with other systems/services can be tested and commissioned into service.

For each services interface the relevant contractors, consultants, suppliers must be present with the principal contractor or his appointed agent undertaking the overall programming control and co-ordination

34.3.3 Combined Services Final Testing And Commissioning

The PBC (with the assistance of the Service Consultants) should produce test schedules with details of;

Test to be conducted for each possible operational condition;
Testing sequence and required results;
Equipment required for testing, commissioning;
Personnel to be present for each test;
The required final test report.

(Refer to item 1.7 for an example of the above requirement.)

34.4 Services

The following services generally interface with or rely on another service;

Electrical
Heating, Ventilation & Air-conditioning
Sprinkler & Fire Protection
Smoke Extraction
Lifts
Escalators
Fire Pumps
Domestic Water Pumps
Sump Pumps
Smoke Detection
Ventilation
Access & Security
Building Management System
Public Address

34.5 Possible Building Operational Conditions

The generic operational conditions are;

Normal conditions
Mains power failure (short duration)
Mains power failure (extended duration)
Fire condition, mains power available
Fire condition, during Mains power failure

Mains power failure during fire condition

Project specific operational conditions should be added as required;

34.6 Brief Overview of Tests

Tests should be carried out demonstrating the correct operation under each possible operational condition.

34.6.1 Normal Conditions

All services to be operational as they would under normal conditions.

34.6.2 Mains Power Failure (Extended Duration)

All services to be operational as they would under normal conditions

Simulate mains power failure.

Ensure correct operation of all essential services.

Re-instate mains power.

Ensure all services return to normal operation.

34.6.3 Mains Power Failure (Short Duration)

All services to be operational as they would under normal conditions

Simulate mains power failure and after 30 seconds re-instate mains power.

Ensure all services return to normal operation.

Simulate mains power failure and after 5 seconds re-instate mains power.

Ensure all services return to normal operation.

34.6.3 Fire Condition

All services to be operational as they would under normal conditions

Simulate fire condition in single fire zone.

Ensure correct start-up / shutdown and operation of equipment as required by the fire engineer.

Reset alarm.

Ensure all services return to normal operation.

Repeat test for each fire zone.

Simulate fire condition in multiple fire zones.

Ensure correct start-up / shutdown and operation of equipment as required by the fire engineer.

Reset alarm.

Ensure all services return to normal operation.

34.6.4 Fire Condition During Power Failure

All services to be operational as they would under normal conditions

Simulate mains power failure.

Ensure correct operation of all essential services.

Simulate fire condition in single fire zone.

Ensure correct start-up / shutdown and operation of equipment as required by the fire engineer.

Reset alarm.

Ensure all services return to normal operation.

Repeat test for each fire zone.

Simulate fire condition in multiple fire zones.

Ensure correct start-up / shutdown and operation of equipment as required by the fire engineer.

Reset alarm.

34.6.5 Power Failure During Fire Condition

All services to be operational as they would under normal conditions

Simulate fire condition in single fire zone.

Ensure correct start-up / shutdown and operation of equipment as required by the fire engineer.

Simulate mains power failure.

Ensure correct re-start and operation of equipment as required by the fire engineer.

Simulate fire condition in single fire zone.

Ensure correct start-up / shutdown and operation of equipment as required by the fire engineer.

Re-instating mains power

Ensure correct re-start and operation of equipment as required by the fire engineer.

Reset alarm

Ensure all services return to normal operation.

34.7 Test Schedules

All tests, timings, settings and readings of all relevant devices as well as corrective action for system failure to be recorded and attached to the completed testing schedules.

Sample test schedules are included for reference.

SERVICES CO-ORDINATED TESTING SCHEDULE

Project Reference	
Test Co-Ordinator	

TEST 1

TEST TO VERIFY THE CORRECT SYSTEMS OPERATION UNDER NORMAL CONDITIONS

DATE | TIME ALLOCATED

ACTION		ATTENDANCE	VERIFIED	COMMENT
	Ensure all services are operating i.e lights, air conditioning, lifts, escalators, ventilation fans, domestic water pumps, fire alarm panel, fresh air fans, all electronic systems, parking control, staircase pressurisation fans, cooking extract fans.		× / ✓	
	Ensure diesel generators, fire pumps, smoke extract fans are set on auto		× / ✓	

SERVICES CO-ORDINATED TESTING SCHEDULE

Project Reference	
Test Co-Ordinator	

TEST 2

TEST TO VERIFY THE CORRECT SYSTEMS OPERATION UNDER LONG DURATION MAINS FAILURE CONDITIONS

DATE | TIME ALLOCATED

ACTION		ATTENDANCE	VERIFIED	COMMENT
	Ensure all services are operating i.e lights, air conditioning, lifts, escalators, ventilation fans, domestic water pumps, fire alarm panel, fresh air fans, all electronic systems, parking control, staircase pressurisation fans, cooking extract fans.		× / ✓	
	Ensure diesel generators, fire pumps, smoke extract fans are set on auto		× / ✓	
Trip Mains Power	Generators to start up, run up to speed and send signal to Main L.V. Board/s to activate changeover			
	Emergency Lighting to remain operational		× / ✓	
	Change over to take places within 15 seconds of power failure.		× / ✓	
	Schedule of equipment to run on generators to be produced, and checked		× / ✓	
	The delayed start up times of the above loads to be measured and recorded.		× / ✓	
Re-instate Mains	The essential loads to continue running on generator supply for +/- 30 seconds		× / ✓	
	Change over from generator to mains at Main LV. Board/s to take place		× / ✓	

SERVICES CO-ORDINATED TESTING SCHEDULE

Project Reference	
Test Co-Ordinator	

TEST 3

TEST TO VERIFY THE CORRECT SYSTEMS OPERATION UNDER SHORT DURATION MAINS FAILURE CONDITIONS

DATE | TIME ALLOCATED

ACTION		ATTENDANCE	VERIFIED	COMMENT
	Ensure all services are operating i.e lights, air conditioning, lifts, escalators, ventilation fans, domestic water pumps, fire alarm panel, fresh air fans, all electronic systems, parking control, staircase pressurisation fans, cooking extract fans.		× / ✓	
	Ensure diesel generators, fire pumps, smoke extract fans are set on auto		× / ✓	
Trip Mains Power	Generators to start up, run up to speed and send signal to Main L.V. Board/s to activate changeover			
	Emergency Lighting to remain operational		× / ✓	
	Change over to take places within 15 seconds of power failure.		× / ✓	
Re-instate Mains	The essential loads to continue running on generator supply		× / ✓	
Trip Mains Power After 2 seconds	The essential loads to continue running on generator supply		× / ✓	
Re-instate Mains	The essential loads to continue running on generator supplied for +/- 30 seconds		× / ✓	
Trip Mains Power During Generator Rundown Period	Generators to take load immediately		× / ✓	
Re-instate Mains	The essential loads to continue running on generator supply+/- 30 seconds		× / ✓	
	Change over from generator to mains at Main LV. Board/s to take place		× / ✓	

SERVICES CO-ORDINATED TESTING SCHEDULE

Project Reference	
Test Co-Ordinator	

TEST 4

TEST TO VERIFY THE CORRECT SYSTEMS OPERATION UNDER FIRE CONDITIONS

DATE | TIME ALLOCATED

ACTION		ATTENDANCE	VERIFIED	COMMENT
	Ensure all services are operating i.e lights, air conditioning, lifts, escalators, ventilation fans, domestic water pumps, fire alarm panel, fresh air fans, all electronic systems, parking control, staircase pressurisation fans, cooking extract fans.		× / ✓	
	Ensure diesel generators, fire pumps, smoke extract fans are set on auto		× / ✓	
Activate Fire Alarm (Zone 1)	Ensure alarm is audible		× / ✓	
	Schedule of equipment to run on fire signal to be produced, and checked		× / ✓	
	Cause and Effect Schedule to be produced, and checked		× / ✓	
Reset Fire Alarm	Ensure audible alarm stops		× / ✓	
	Ensure all equipment returns to normal operation.		× / ✓	
Activate Fire Alarm (Zone x)	Repeat test for all zones		× / ✓	

SERVICES CO-ORDINATED TESTING SCHEDULE

Project Reference	
Test Co-Ordinator	

TEST 5

TEST TO VERIFY THE CORRECT SYSTEMS OPERATION UNDER FIRE CONDITIONS DURING POWER FAILURE

DATE | TIME ALLOCATED

ACTION		ATTENDANCE	VERIFIED	COMMENT
	Ensure all services are operating i.e lights, air conditioning, lifts, escalators, ventilation fans, domestic water pumps, fire alarm panel, fresh air fans, all electronic systems, parking control, staircase pressurisation fans, cooking extract fans.		× / ✓	
	Ensure diesel generators, fire pumps, smoke extract fans are set on auto		× / ✓	
Trip Mains Power	Generators to start up, run up to speed and send signal to Main L.V. Board/s to activate changeover			
	Emergency Lighting to remain operational		× / ✓	
	Change over to take places within 15 seconds of power failure.		× / ✓	
Repeat Test 4				

SERVICES CO-ORDINATED TESTING SCHEDULE

Project Reference	
Test Co-Ordinator	

TEST 6

TEST TO VERIFY THE CORRECT SYSTEMS OPERATION OF MAINS POWER FAILURE UNDER FIRE CONDITIONS

DATE | TIME ALLOCATED

ACTION		ATTENDANCE	VERIFIED	COMMENT
	Ensure all services are operating i.e lights, air conditioning, lifts, escalators, ventilation fans, domestic water pumps, fire alarm panel, fresh air fans, all electronic systems, parking control, staircase pressurisation fans, cooking extract fans.		× / ✓	
	Ensure diesel generators, fire pumps, smoke extract fans are set on auto		× / ✓	
Activate Fire Alarm (Zone 1)	Ensure alarm is audible		× / ✓	
	Schedule of equipment to run on fire signal to be produced, and checked		× / ✓	
	Cause and Effect Schedule to be produced, and checked		× / ✓	
Trip Mains Power	Generators to start up, run up to speed and send signal to Main L.V. Board/s to activate changeover			
	Emergency Lighting to remain operational		× / ✓	
	Change over to take places within 15 seconds of power failure.		× / ✓	
	Equipment to re-start in fire mode, running on generator .		× / ✓	
Re-instate Mains	The fire loads to continue running on generator supplied for +/- 30 seconds		× / ✓	
	Change over from generator to mains at Main LV. Board/s to take place		× / ✓	
	Equipment to re-start in fire mode		× / ✓	
Reset Fire Alarm	Ensure audible alarm stops		× / ✓	
	Ensure all equipment returns to normal operation.		× / ✓	

34.8 Safety

Appropriate equipment to be provided to ensure the safe undertaking of the testing, including two way radios for communication between various parties, Hearing protection for persons in generator / plant rooms, torches and safety lighting.

All persons on site are to be made aware of the test schedule.

34.9 Operation And Maintenance Manuals

Completed testing schedules are to be included in the relevant manual.

The system overview, how the system operates under the various building functional conditions and the remedial action should the system fail to operate correctly for the various building operational conditions should be included in the manual.