MOKOLO AND CROCODILE WATER AUGMENTATION PROJECT PHASE 2 (MCWAP-2)

TENDER NO 054/2024/PMID/MCWAP2/RFB

PART C3.1
SPECIFICATION

SECTION 39

ELECTRICAL – PLANT AND INSTALLATION

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

SECTION 39

ELECTRICAL - PLANT AND INSTALLATION

39.1 GENERAL

39.1.1 Scope of Work

This Section is a standard specification for electrical Plant installations and shall be read in conjunction with Section 38 – Electrical General which covers particular electrical installation requirements for this Contract and relevant electrical design standards.

This Section shall be interpreted as the Employers requirements for aspects designed by the Contractor.

39.1.2 References

When reference is made to a Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise in writing by the Engineer.

39.1.3 Design and Manufacturing Standards

Contractors should also note that it is not possible to specify everything required for this project in its minute detail and it is therefore a requirement that the Contractor shall, in view of the required extensive experience, adequately allow for such minute details, in order to neatly round off the project as a whole to the full approval of the Engineer and to the satisfaction of the Employer.

It is the responsibility of the Contractor appointed in terms of the Contract to ensure that all switchgear, cables, transformers, associated auxiliary Plant and components called for in this Specification shall be suitable for the safe operation, under all the climatic conditions as specified.

It is the responsibility of the Contractor to correctly position and securely install all Plant, switchgear, conduits, wiring channels, cables, cable racks and trays, distribution boards, fittings and accessories as required for the installation. The Contractor shall supply and install all necessary supports, brackets, hangers etc.

All Plant called for in this specification, shall in all respects comply with the requirements detailed in the latest editions of the relevant Specifications, as listed above, for the various components. Exemption of any kind shall be formally documented in writing.

39.1.4 Workmanship and Quality Control

The Contractor (Electrical Contractor) shall only use qualified and experienced personnel for this project.

The onus is on the Contractor to produce work which conforms in all respects to the quality and accuracy as detailed in this specification and drawings. The Contractor shall therefore at his own expense institute an approved quality control system and provide experienced engineers, foreman, surveyors, technicians and Plant to ensure adequate supervision and positive control of the works and materials at all times.

The cost of all supervision and process control, including testing and commissioning and the keeping of accurate quality control and photo records so carried out by the Contractor, shall be deemed to be included in the rates tendered for the related items of work.

The Contractor shall be responsible for the performance of the works during the various phases of construction. He shall provide all Plant and accessories and all working arrangements necessary to do the work and to limit stresses on the works, so that stability of structures will not be threatened and so that stresses and deformation will remain within acceptable limits.

39.1.5 Safety

The Contractor shall take full responsibility for the prevention of unsafe working conditions and practices and for the promotion of safe working conditions and practices at site, and shall at all times meet the requirements of the Occupational Health and Safety Act 85 of 1993 a.a., including the Employer's Health and Safety Policy and Site Induction documentation, where applicable.

The Contractor shall always ensure that approved safety Plant be worn by all persons, at all times, at the work sites, which will include amongst others suitable clothing, helmets, footwear etc.

The Contractor shall conduct safety awareness programmes and campaigns during the Contract and shall furthermore obtain, erect and maintain applicable and necessary safety notices to the approval of the Engineer.

The Contractor shall implement a specific safety policy and appoint a safety officer, who shall be responsible to ensure that all safety requirements are always adhered to. Regular safety meetings shall be held, and minutes of such safety meetings shall be kept by the safety officer.

The Contractor shall also be required to take care in respect of the safety of public, other Contractors or workers, in and around his work areas.

39.1.6 Fixing and Mounting Details

39.1.6.1 Installation Materials and Finishing

Special care shall be taken in the selection and assembly of all Plant, to ensure that all components, including bolts, nuts washers, spring washers, mounting rails, base plates, cable glands and all associated Plant are of suitable materials to prevent corrosion.

All bolts, nuts, washers and spring washers shall either be of the stainless steel or hot dip galvanised type. Under no circumstances will any mild steel or cadmium plated bolts and nuts be allowed on this project. Contractors intending the use of any brass bolts, nuts or washers shall clarify this in writing with the Engineer prior to manufacturing or assembly of any of these components.

Special care shall be taken in the design and selection of components to avoid contact between any metals which will result in electro chemical corrosion, such as for example between brass and aluminium. Any uncertainties shall be clarified with the Engineer in writing prior to the application thereof.

39.1.6.2 Painting of Brackets and Supports

All steel support brackets, lugs, etc., shall be painted in accordance with this section before installation. All such items with damaged paintwork shall be repaired before final securing of the Plant or cables. Galvanized articles and all galvanized trays need not be painted unless otherwise specified in Section 38 – Electrical General, but shall be clean and free of paint spot, grease, or any other foreign matter.

39.1.6.3 Fixing to Structural Steel and Machinery

Supports, brackets, hangers, etc., may only be welded or drilled and bolted to structural steel members where prior permission from the Engineer for this has been obtained. “CADDY” or similar fasteners may not be used to fix Plant to structural steel or machinery.

Welding of brackets or straps onto machinery, hoppers, chuting or pipework will not be permitted.

39.1.6.4 Screws and Bolts

Where holes exist in Plant to be fixed, the largest bolt or screw that will fit into the prepared hole shall be used.

39.1.6.5 Wall Plugs

Where the fixing holes in brick or concrete walls are smaller than 10 mm diameter and where the mass of the Plant to be fixed is less than 10 kg, wall plugs may be used to fix the Plant (for example fittings and accessories). “Fischer” or equal approved plastic plugs shall be used. Plugs installed in joints between bricks are not acceptable. A masonry drill of the recommended size shall be used to drill holes for plugs. Screws of the correct diameter and type to match the specific plug shall be used.

39.1.6.6 Anchor Bolts

Where the fixing holes are 10 mm and larger or where the mass of the Plant is 10 kg or larger, the Plant shall be fixed by means of expanding anchor bolts or by means of bolts cast into the concrete or built into brick walls.

39.1.6.7 Shot-fired Type Fixing

Shot-fired type fixing will only be permitted for specific purposes and provided written permission has been obtained from the Engineer.

39.1.6.8 Fixing of Cable Trays and Ladders

All trays and ladders shall be fixed to rigid steel brackets. Trays shall not be fixed directly against any mounting surface but shall be spaced away from surfaces by approximately 25 mm. Brackets shall be fixed to ceilings or walls at regular intervals to ensure no noticeable deflection of the trays between support points.

The widths of cable trays shall be adequate for the number of cables with spacing as specified (including provision for future extension).

All fixings to concrete surfaces shall be by means of screws in drilled and plugged holes or anchor bolts, depending on the size of the tray or ladder.

Cables run along sections of structural steelwork and/or chuting or pipework shall also be run on trays with suitable supporting members which may be bolted to the structural steelwork, chuting or flanges of the pipework. Where cables are run on any part of machinery these shall not interfere with the operation of the machine or access to it for maintenance or dismantling for repair.

Clamps and brackets used to fix or support Plant such as cable trays, ladders, ducts, etc., shall be of a purpose-made type suitable for the specific application.

Short lengths (i.e. up to 2 metres) of PVC / SWA / PVC cables may be installed inside conduits for fixing to structural steel or machinery. Where this occurs, the conduit shall be fitted at each end with a female bush and the ends of the conduits totally sealed after installation of the cable.

39.1.7 Painting of Steelwork

39.1.7.1 General

The following requirements are for the surface preparation and subsequent painting of all steelwork associated with electrical Plant except mass produced and proprietary items. It is accepted that detailed painting procedures cannot be insisted upon in the case of mass produced and proprietary items but details of the surface preparation and treatment of any such items must be submitted to the Engineer for final approval.

Where control of surface finish and protective coatings is essential and the painting procedure of the Contractor does not comply fully with Section 37 – Painting and Corrosion Protection, the resultant protection must give an equivalent life performance. In all cases, the Contractor must state compliance or otherwise with Section 37 – Painting and Corrosion Protection.

39.1.7.2 Surface Preparation

Refer to Section 37– Painting and Corrosion Protection.

39.1.7.3 Priming

Refer to Section 37 – Painting and Corrosion Protection.

39.1.7.4 Finishing

Refer to Section 37 – Painting and Corrosion Protection.

39.1.7.5 Repairing Paintwork

Refer to Section 37– Painting and Corrosion Protection.

39.2 CABLES

39.2.1 Standards

All cables and cable installations shall comply with the latest applicable revision of the following standards:

SANS 97	Electric cables — Impregnated paper insulated metal-sheathed cables (PILC) for rated voltages 3,3/3,3 kV to 19/33 kV
SANS 1339	Electric cables — Cross-linked polyethylene (XLPE) insulated cables for rated voltages 3,8/6,6 kV to 19/33 kV
SANS 1507 Part 1-6	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SANS 10142	The wiring of premises
SANS 10198 Part 1-13	The selection, handling and installation of electric power cables of rating not exceeding 33 kV
BS 4579	Specification for performance of mechanical and compression joints in electric cable and wire connectors

39.2.2 General

a) Cables shall be as specified in the cable schedules and/or as shown on the Drawings. Cable lengths shown on the cable schedule are approximate lengths only. Final lengths will be determined on Site.

b) Only armoured cables shall be used for underground cable runs, whether installed in pipes or laid in the ground. Unarmoured cables may only be used when installed in conduit or enclosed metal ducts along the entire cable route.

c) All cables installed on the cable trays, in floor trenches, in vertical riser ducts and all cable runs that are partially installed in conduits, underground pipes or metal ducts, shall be fully armoured.

d) All cables shall comply with the relevant SANS, EDC or NEMA specifications and shall be installed, fixed, protected and terminated in a proper fashion according to approved methods and in accordance with the manufacturer's specifications and the Code of Practice for the Wiring of Premises, SANS 10142. The Contractor shall employ competent staff for the installation of the various cable types.

e) Cables with conductor sizes of less than 1,5 m² shall not be used except for communication or control systems where the supply voltage is less than 50 V. Only cables with copper conductors shall be used unless approved otherwise.

f) Cable sizes shall be determined strictly in accordance with the relevant tables of the Code of Practice of the Wiring Premises, SANS 10142. Special attention shall be paid to group de-rating factors and cables sized for Plant requiring low voltage drops (especially in the case of motors starting high inertia loads). Cables spaced apart by a minimum of 2 cable diameters need not be de-rated.

g) All accessories, tools and termination and jointing kits shall be of an approved type and in accordance with the cable manufacturer's recommendations.

h) All cable jointing and termination accessories used for MV power distribution shall be approved by the Engineer.

i) Through joints will not be allowed in cables without the written permission of the Engineer or his Representative.

j) Unless clearly specified to the contrary, each cable run which forms part of the low tension distribution system, and each cable feeding Plant, shall be provided with an earth continuity conductor. The earth conductor size shall be selected in accordance with SANS 10142. No earth continuity conductor shall be less than 2,5 mm².

k) The earth continuity conductor shall consist of:

   i) A separate un-insulated stranded copper conductor installed along the same route as the associated cable; or

   ii) one of the cable conductors; or

   iii) The armouring of an armoured cable shall be connected to the earth continuity conductor at both cable ends and at all joints. The cross-sectional area of the armouring at joints shall not be reduced and shall be made continuous across joints.

l) Mineral insulated cables shall comply with the relevant standards and shall be provided with a seamless copper sheath.

m) Aluminium sheathed cables shall be PVC insulated and protected by a seamless aluminium sheath and PVC outer sheath and shall be of “SURFIX” type or equal approved.

n) Any other cables to be used by the Contractor, i.e. telephone, control, flexible cords, etc., are specified in detail by the Engineer on the relevant cable schedule or data sheet.

39.2.3 Competence of Personnel

The Contractor shall only employ personnel who are fully conversant with the cable manufacturer's recommendations for jointing and terminating of cables rated greater than 1000 volts.

39.2.4 Identification of Cables

Each cable shall be clearly marked at both ends with the correct cable number with cable marking tags of “Bowthorpe Hellerman” type or equal approved.

The use of PVC tape for tags, with punched characters is not acceptable.

The identification numbers of cables shall be shown on all as-built drawings and cable schedules for the complete installation.

39.2.5 Paper Insulated Cables

Paper insulated cables shall comply with SANS 97 and shall be of the (PILCSWA) mass-impregnated or pre-impregnated non-draining belted type. The conductors shall be of copper.

All joints and terminations shall be made either by means of compound filled boxes or by means of epoxy resin materials. Epoxy resin joints and terminations shall be made entirely in accordance with the manufacturer's instructions and with the materials stipulated.

If a cable is cut and will be exposed to the atmosphere for more than 2 hours, the cable ends shall be sealed and wiped to prevent the ingress of moisture.

39.2.6 PVC Insulated Armoured Cables

All PVC / SWA / PVC cable shall comply with SANS 1507-3 and shall consist of PVC insulated copper conductors, PVC bedding, galvanised steel wire armouring and an extruded PVC outer sheath.

Cable ends shall be terminated in approved cable glands to ensure a moisture proof connection between the outer sheath, gland and Plant.

In cases where copper earth conductors are included in the armouring (ECC/SWA cables), special glands in accordance with SANS shall be used.

Cable glands shall be of the type in which the armouring is clamped between tapered cones, tightened down and fitted to a cable gland plate or Plant housing by means of locknuts.

A neoprene shroud shall cover the gland externally and form an effective seal with the outer sheath of the cable.

39.2.7 XLPE Cables

Cross linked Polyethylene (XLPE) cables shall have individually screened conductors and be steel wire armoured.

Joints and terminations shall be made entirely in accordance with the manufacturer's instructions and with the materials stipulated in such instructions.

39.2.8 Installation of Cables

Lugs shall be crimped to cable core ends using mechanical or hydraulic tools designed for this purpose. Evidence may be requested that the crimping method used complies with the performance requirements of BS 4579, Part 1. Cables that are connected to clamp type terminals where the clamping screws are not in direct contact with the conductor, need not be lugged but the correct terminal size shall be used. Contact surfaces shall be thoroughly cleaned, and smoothed and fixing bolts shall match the hole size of the lug.

Medium tension cables (voltages in excess of 600 V phase to earth) shall be installed away from other cables in separate sleeves or ladders.

Single core cables for 3 phase supplies shall be installed in trefoil formation, with cables being in physical contact and tied together at 0,5 m intervals with 10 layers of 3M fibre glass tape.

Cables in floor trenches shall not be bunched in random fashion but shall be installed parallel to each other. All floor trenches shall be covered with chequer plate.

The internal radius of a bend of a cable shall not be less than 12 times the overall diameter in the case of a paper insulated or XLPE cable and not less than 10 times the overall diameter in the case of a PVC insulated cable.

Parallel cable runs on cable trays, etc. shall be separated by a minimum of 2 cable diameters unless otherwise specified.

Where cable clamps are used, they shall be of non-combustible material and shall be of the correct size for the cable.

All cables shall be marked at both ends and at all joints by means of non-corroding metal bands with punched or raised numbers. The numbers shall appear on the "as installed" drawings.

39.2.9 Installation of Underground Cables

39.2.9.1 Cable Trenches

The Contractor shall, before trenching commences, familiarise himself with the cable routes, Site conditions and the procedures to be followed, in particular the existence of any services that might cross or lie near the route.

All trenches shall be inspected and approved by the engineer before laying of cables with bottom bedding in place as well as after the cables have been installed with the top bedding in place. No trench shall be backfilled unless the above inspections were carried out and the trenches approved by the Engineer.

39.2.9.2 Installation Depths

Unless otherwise indicated on the installation Drawings, cables shall be installed at the following minimum depths below final ground level:

- Up to 1 kV : 600 mm
- Above 1 kV : 800 mm

All cable depth measurements shall be made to the top of the cable when laid directly in ground or to the top of the duct or sleeve where these are provided.

The above depths shall apply to the top layer where groups of cables are installed in layers.

The Contractor may only deviate from the above depths when approval in writing has been obtained from the Engineer.

39.2.9.3 Cable Spacing

Cables installed in the same trench shall be laid parallel to each other with the following spacing between cables.

- Between LV cables : 50 mm
- Between LV and MV : 300 mm minimum
- Between MV and MV : 300 mm minimum

Where MV and LV cables must be installed in the same trench, the MV cable shall be laid on the one side of the trench at the correct depth and then partly covered. The LV cable shall then be

laid on the other side of the trench and at the correct depth, i.e. not above the MV cable, and then the trench completely backfilled.

Cables for telephones, communication systems and control systems shall be separated from power cables by at least 300 mm.

Cables shall not be laid on top of each other but, in the case of groups, in layers. The minimum vertical spacing between layers shall be 200 mm.

39.2.9.4 Cable Laying

Except where ducts, tunnels or pipes are provided, cables shall be laid directly in the ground.

When laying cables in trenches excavated in soft or hard material or containing sharp stones, rocks or other items likely to damage cables, the following precautions shall be taken:

a) Before laying the cables all items that could damage the cable shall be removed from the bottom of the trench. The floor of the trench shall then be evenly covered with a layer of sieved backfill or sand to a level which is 150 mm above the highest unevenness of the trench. Sieved backfill shall mean ground having been passed through a 5 mm size sieve.

b) The laying of cables shall not commence until the trenches have been inspected and approved. Cables shall be removed from the drum in such a way that no twisting, tension or mechanical damage is caused, and shall be adequately supported at short intervals during the whole operation. Particular care shall be exercised, where it is necessary to draw cables through pipes and ducts, to avoid abrasion, elongation or distortion of any kind. The ends of such pipes and ducts shall be sealed after the cables have been installed.

c) The cables shall be covered with a 150 mm layer of sieved backfill or sand.

d) Backfilling of the trenches shall be in layers of 200 mm and compacted to a minimum density of 95% in accordance with AASHTO/SABS 1200D.

e) All sieved backfill or sand used for bedding, shall have a soil thermal resistivity of maximum 1,2 K.m/W or lower. It is a specific requirement of this specification that soil thermal resistivity test shall be done to guarantee this requirement and Contractors shall allow for such tests in their prices. These test results shall be provided to the Engineer prior to installation.

f) Where MV and LV cables are installed in the same trench the Contractor shall install the MV cable at 800 mm below ground level and the LV cables at 600 mm below ground level.

g) A continuous PVC warning tape with the wording “Buried Electrical Cable Below – Danger” shall be laid along the full length of the trench approximately 300 mm above the cables.

h) Cable route markers shall be laid, flush with the finished surface at 50 m intervals along straight runs and at each bend or deviation. The markers shall consist of 150 x 150 x 300 mm high concrete blocks with 100 x 100 x 2 mm aluminium plates clearly stamped or engraved “LV Cable” or “MV Cable” as the case may be.

i) The Contractor shall not fill or close any trench until it has been examined and approved by the Engineer.

39.2.9.5 Road Crossings

Cables laid under roads shall be laid in ducts / sleeves, strong and rigid enough to handle the compaction of soil associated with cable installations. All ducts shall be laid to have a minimum depth of cover of not less than 800 mm between the top of the duct and the surface of the road.

All sleeves at road crossings shall be continued at least 500 mm beyond each kerb face. Where sidewalks are introduced, sleeves shall protrude 500 mm beyond the sidewalk.

The location of laid sleeves shall be marked with an ‘E’ embossed into the kerb at both ends. The size of the ‘E’ shall be 100 mm from top to bottom.

150 mm layer of fine sifted earth must be placed on the bottom of the trench to serve as bedding.

After the sleeves have been installed, it shall be covered with 150 mm layer of well-compacted, fine sifted earth.

Particular care shall be taken to keep the sleeves clear of concrete or any substance during construction.

A draw wire shall be provided in each sleeve and be suitably sealed at both ends.

Where work requires the installation of ducts / sleeves / cables under tarred or made-up sections of roads, streets or sidewalks, reinstatement of the surface shall be carried out as directed by the Engineer. The Contractor shall execute and maintain interim restoration.

Where ducts / sleeves or cables are laid in the slopes of road cuttings or in the fill of embankments, the surface and slope shall be restored to the satisfaction of the Engineer.

39.2.9.6 Handling of Cables

The handling and laying of cables shall be performed in accordance with the following:

a) Drums of cable shall not be dropped off trucks. The Contractor shall provide approved off-loading facilities at Site.

b) Cable drums shall be rolled on the ground in the right direction.

c) Care shall be taken not to damage cables when stripping battens from a drum.

d) When winding off a drum, the drum shall always be supported on cable jacks or a cable trailer of sufficient strength to support the weight.

e) When winding off a drum, the drum shall not be allowed to overwind and stress the cable. The maximum speed with which a cable is unwound shall not exceed 10 m/min.

f) Cable rollers shall be used as far as possible to run out cables. Rollers shall be spaced so that the length of cable in the trench will be suspended during the laying operation so as to prevent undue sagging and prevent the cable from touching the ground.

g) Cable rollers shall have no sharp projecting parts liable to damage cables.

h) Where cables must be drawn around corners, well-lubricated skid plates or vertical rollers shall be used and shall be securely fixed and constantly examined during cable laying operations.

i) Where cables have to be drawn through pipes or ducts, an approved type of cable sock shall be used, and particular care shall be exercised to avoid abrasion, elongation or distortion of any kind.

j) The maximum allowable tension when pulling a cable shall be in accordance with the cable manufacturer's recommendations.

k) The inside radius of all bends shall be greater than 12 times the overall diameter of the cable.

l) The Contractor shall further note the following:

i) Cables shall be laid in such a way that the start of a run always joins the end of the run preceding it, so that the rotation of the cores is consistent throughout.

ii) The Contractor shall ensure that adequate slack is allowed for the proper termination or jointing of the cable.

iii) The Contractor shall ensure that all cable ends are protected against moisture ingress as in standard practice.

iv) The Contractor shall be required to keep accurate records of each drum of cable used. The following information shall be provided to the Engineer:

- Drum number;
- Cross sectional area of cable;
- From which reference point to which reference point is used;
- Length of cable left over; and
- Date when cable was laid.

39.2.10 Installation of Cables in Service Ducts

39.2.10.1 General

The following requirements are for the installation of cables in purpose-built brick or concrete trenches, service ducts, etc.

39.2.10.2 Installation

Cables shall be installed using the following methods:

- On horizontal cable trays or racks;
- On horizontal or vertical metal supports with suitable clamps;
- On vertical cable trays or racks fixed to the side of the service duct;
- In all cases the cables shall be clamped or strapped in position; and
- Cables shall not be bunched and laid on the floor of the service ducts or trenches.

39.2.10.3 Covers

The Contractor shall be responsible for the cutting or drilling and smoothing of holes for cables through chequer plates, concrete or other coverings as required including reinstatement of corrosion protection to the satisfaction of the Engineer.

39.2.10.4 Filled Trenches

Where specified, service ducts shall be filled with sand.

If a sand filling is specified, the cables shall be fixed to non-corroding supports.

Sand-filled trenches other than in substations shall be covered as follows:

- Reinforced concrete covers (where vehicles cross service ducts);
- Sand and cement screed; and
- Removable chequer plates.

39.2.11 Cables Installed on Cable Racks and Trays

39.2.11.1 Installation

Cables may be installed and supported as follows and this will be indicated on the Drawings:

- On horizontal cable racks or trays;
- On vertical cable racks or trays;
- On horizontal or vertical metal supports or brackets with approved type clamps; and
- On special “cleats” or clamps which are fixed to the structure.

39.2.11.2 Clamps

Approved type clamps or cleats which will secure cables without damage may be used. Drilled hard wood blocks are acceptable. The correct clamp size to fit the cable shall be used. Cables of different sizes shall not be fixed by a common clamp.

39.2.11.3 Spacing Correction Factors

Cables shall be spaced a minimum of two cable diameters apart, for which no grouping correction factor need be applied.

39.2.11.4 Cables on Different Levels

Where parallel cable runs are installed at different levels (e.g. on parallel cable trays) and where the spacing of the layers is not specified, a minimum vertical spacing of 300 mm between cables shall be maintained.

39.2.11.5 Single Core Cables

Where single core cables are installed along a three- phase circuit, the cables shall be installed in trefoil formation and strapped together at 300 mm intervals.

39.2.11.6 Medium Voltage Cables

Medium voltage cables shall be separated from other cables and services throughout the installation and shall as far as possible be installed in separate service ducts, pipes or racks and trays. Where this is not possible a minimum spacing of 300 mm between cables shall be maintained.

39.2.11.7 Cables for other Services

Cables for telephones, communication and control systems shall be separated from power cables. In service ducts a metal barrier shall be provided between power cables and cables for other services. Where armoured cables are used for such other services, they shall be installed on separate cable trays or shall otherwise be at least 300 mm away from power cables.

39.2.11.8 Method of Installation

Cables shall be laid neatly on trays and racks with a minimum of crossovers. The Engineer reserves the right to condemn any cabling that does not reasonably conform to acceptable practical standards. Multicore cables shall be run on cable trays or racks and will not be permitted to be run in power trunking.

Cables shall be fixed and supported by means of approved clamping devices or cable ties. These devices shall not damage the cable in any way and shall ensure that the cable remains in the installed position. They shall be spaced at adequate intervals to prevent any sagging of the cable.

Cables of 25 mm diameter and larger shall be saddled or clamped individually. Cables of 15 mm diameter to 25 mm diameter may be saddled or clamped in pairs provided such cables are of identical diameter. Cables smaller than 15 mm diameter may be saddled or clamped in groups not exceeding three provided such cables are of identical diameter.

39.2.12 Cable Racks and Trays

39.2.12.1 Cable Trays

Perforated cable trays with a minimum thickness of 1.6 mm shall be provided to support all power, control, indication and main lighting cables. All cable trays and associated accessories shall be of an approved manufacture and the material shall be as specified in Section 38 – Electrical General.

39.2.12.2 Cable Racks

Heavy duty cable racks shall be used and shall be of an approved manufacture. The material shall be as specified in Section 38 – Electrical General.

39.2.12.3 Curves and Sets

Where sets and changes of direction occur in the cable routes, curved sections of trays and racks shall be properly radiused to suit the cables being carried. All special sets and curves required in the trays shall be neatly executed to the satisfaction of the Engineer.

39.2.13 Routing of Cables

The routes of the main cables and approximate positions of the motors and electrical Plant are indicated on the Drawings. The routes of all secondary cables shall be determined by the Contractor in consultation with the Engineer.

Where cables are exposed to the possibility of mechanical damage, they shall be run in a galvanized conduit or pipe or protected with metal covers or guards to the approval of the Engineer.

Where cables must cross a floor area to a connection or termination point, the cables shall be run so as not to obstruct any passageway. Metal covers or guards bolted to the floor will not be acceptable; and in such instances the cable shall be run in under floor conduits or ducts.

39.2.14 Termination and Jointing of Cables

39.2.14.1 General

Joints in cables will not be permitted unless approved by the Engineer or detailed on a schedule or Drawings.

Where jointing is permitted it shall be carried out in accordance with the manufacturer's recommendation and by personnel competent in jointing the types of cables used. Approval of the type of jointing kit for MV and LV cables shall be obtained from the Engineer.

During outdoor jointing operations, the jointing area shall be covered by tents of waterproof material suitably supported. Where necessary a trench shall be excavated around the area to prevent the ingress of water. The sides of the excavation shall be draped with tarpaulins or plastic sheeting to keep the area clean during jointing operations.

The Contractor shall notify the Engineer whenever jointing is to be carried out so that an inspection may be undertaken if required. Any cable joint installed by the Contractor without the knowledge or approval of the Engineer may be rejected and may result in a new length of cable being installed at the Contractor's expense.

The crossing over of cores in joints will not be permitted.

39.2.14.2 LV PVC / SWA / PVC Cables

Cable ends shall be terminated with approved type cable glands complete with shrouds, earth tags etc., similar or equal to those supplied by “Pratley”.

All cable ends shall be bonded to the main earth connection.

Cable cores shall be marked with approved type marking sleeves where necessary to identify the phases and/or core numbers.

Cables shall be terminated in accordance with the recommendations laid down by the manufacturers of the cables and cable glands and the correct size of gland for the particular size of cable shall be used in accordance with the recommendations.

Where cables are terminated at a distribution board, control desk or motor control centre, sufficient space shall be allowed between each gland to allow for accessibility of tools to tighten / loosen relevant lock nuts and for the installation of cable markers as specified. Spacing shall be a minimum of 50 mm between the outside diameters of locknuts unless specified otherwise in Section 38 – Electrical General.

All glands shall be properly installed and effectively earthed to the satisfaction of the Engineer. Each gland for armoured cables shall be complete with neoprene shrouds and earth tags.

Earthing tags on glands shall be securely clamped to the enclosure by means of a brass screw which passes through the inside of the enclosure. The brass screw shall be effectively connected to the earth terminal inside the enclosure in order to maintain earth continuity.

Glands used for ECC armoured cables shall be provided with suitable accessories to facilitate a bolted lug connection of the earth continuity conductor. Grooves cut into the barrel or cone bush to accommodate the earth continuity conductors shall not be permitted.

39.2.14.3 XLPE Cables

XLPE cables shall be terminated in accordance with the manufacturer's instructions.

The copper tapes of the earth screen on the cable shall be bonded to the main earth bar of the switchgear or transformer and shall be easily removable for testing the efficiency of the earth connections.

The cable shall be firmly secured by means of a clamp to prevent mechanical stress on the cable and terminations.

39.2.14.4 Connection of Cable Conductors

Conductors of cables shall be connected to Plant with approved lugs, which shall be crimped, using mechanical or pneumatic tools designed for the purpose.

Contact surfaces shall be thoroughly cleaned and smoothed and fixing bolts shall match the whole size of the lug.

Cables that are connected to clamp type terminals, where the clamping screws are not in direct contact with the conductor, shall be fitted with pin-lugs suitable for the cross-sectional area of the relevant cable.

When cutting away insulation from cable conductors to fit into lugs, care shall be taken that no strands are left exposed. Under no circumstances shall any of the conductor strands be cut away to fit into lugs.

Torque wrenches shall be used to tighten screw-joints of copper bars as well as bolting cable lugs onto copper bars, battery terminating plates and motor terminals to consistent and reputable values.

39.2.15 Testing of Cables

Each cable shall be ‘Megger’ tested after installation for insulation damage. MV cables, joints and terminations shall be pressure tested by a specialist Contractor (XLPE cables shall be tested in accordance with the manufacturer’s recommendations).

The Contractor shall make all arrangements, pay all fees and provide all Plant required for these tests.

The Contractor shall notify the Engineer within the time as specified in Section 38 – Electrical General so that he may witness the tests.

On completion of the tests on any cable, the Contractor shall submit copies of each certified Test Report to the Engineer.

39.3 WIRING, CONDUITS AND ACCESSORIES

39.3.1 Wiring

All wiring used shall be 600/1000 V PVC insulated, single core multi stranded copper conductors and green PVC insulated copper conductors for earth continuity (no bare stranded copper).

All conductors shall be installed in wire ways, cable channels or power skirting of metal unless otherwise approved. Exposed conductors at any point will not be allowed.

Conductors from different switchboards may not be installed in the same wire way or cable channels. The number of conductors in a conduit shall comply with the requirements of SANS 10142.

The combined total cross-sectional area (including insulation) of conductors installed in enclosed cable channels may not exceed 40% of the cross- sectional area of the channel.

Conductors for power, control DC supply, telephone and other services shall be installed in separate conduits for each separate service or system. Conductors for power and control of motor circuits only may be run in the same conduit, provided the insulation of the control wiring is of the same voltage grade as that of the power wiring.

Conductor sizes shall be determined strictly in accordance with the relevant tables for current ratings and voltage drops as listed in SANS 10142. Generally, the following will apply unless otherwise specified:

CIRCUIT	POWER CONDUCTOR	EARTH CONDUCTOR
Lighting	2,5 mm²	2,5 mm²
Power	4,0 mm²	2,5 mm²

The colour of conductors shall be as follows:

- 3-phase: Red / White / Blue
- Single-phase: Red
- Neutral: Black
- Earth: Green
- Emergency power: Purple
- UPS Power: Brown
- Return circuit from lights: Grey

Only insulated earth wires will be accepted unless bare earth conductors have been approved by the Engineer in writing.

All sub-circuit wiring shall be carried out using the looping-in method for outlets or Plant on the same circuit.

Joints shall be kept to a minimum and shall only be made in accessible outlet boxes, distribution boards or terminal boxes and only approved connectors or terminal rails shall be used.

Where two circuits are drawn through the same conduit, neither circuit will be permitted to pass through the termination point (switch or socket outlet, etc.) of the other circuit. A three-way conduit box shall be fitted, before the first termination point, in which the circuits shall be fed through separate conduits to the termination points. Not more than 2 ends will be allocated at any outlet point.

AC circuits installed in conduit shall have the wires for all phases and neutral contained in the same conduit.

Where the conductors of more than one circuit are present in wire ways, cable channels or power skirting, the conductors of each circuit, including earth conductors, shall be taped together at intervals of 1 m. The conductors of the various circuits shall, however, be separate in order that any circuit can be withdrawn. Circuits are to be marked at 3 m intervals when installed in trunking and/or power skirting.

Conductors installed in vertical conduit or cable duct runs shall be clamped at intervals not exceeding 3 m. The clamps shall be installed in suitable accessible draw-boxes. Clamps are to be of durable insulating material that cannot damage insulation of conductors.

Circuits of different phases may not be present in the same outlet box, switch box or connection point except where three phase Plant is installed.

Wireways and conduits shall not be used as earth continuity conductors. Separate bare stranded copper conductors of appropriate section shall be run for earthing purposes and bonded to the wireways at appropriate points.

Wiring conductors shall not be installed until the entire conduit or wire way for the circuit has been completed and cleaned.

39.3.2 Termination of Conductors

Where earth conductors are installed according to a loop system, all looped connections shall be ferruled to avoid breaking earth continuity when the conductors are removed from any such terminals. Termination to be on the body of outlet box with tail piece to accessory.

The conductor insulation shall only be removed sufficiently for full insertion into the terminal. Bare conductors shall not be visible. (No insulation tape will be allowed).

Conductor strands may not be cut away under any circumstances.

Crimped lugs shall be used for terminations to Plant such as motors and terminal blocks.

Wire end ferrules are to be used at all screwed connections.

39.3.3 Wiring Accessories

39.3.3.1 Mounting Height

Unless otherwise specified in Section 38 – Electrical General, mounting heights shall be as indicated below:

- Light switch: 1400 mm

- Socket outlet: 300 mm
- Telephone / Network outlet: 300 mm
- Socket outlets in kitchens: 1250 mm

The dimension given is the measurement from the centre of the fitting or outlet box above the finished floor level.

All outlets shall be of the flush mounted type unless otherwise specified. All wall and floor outlet boxes shall be galvanised.

Fittings shall be mounted square without openings under cover plates.

Fittings shall have protected terminals for safe wiring.

39.3.3.2 Socket Outlets

SANS 164-1 and SANS 164-2 shall apply.

Socket outlets shall be accurately positioned in accordance with the Drawings.

All Industrial type single phase socket outlets shall be 16 A, 220/250 V and shall be IP65 rated.

All 3-phase socket outlets shall have a minimum rating of 25 Amp. They shall be of the five-pin industrial surface-mounted, switched socket type and each shall be supplied complete with matching plug. The outlets shall be interlocked to prevent switching on if the plug top is not installed and to prevent the removal of the plug-top-in the “ON” position.

39.3.3.3 Light Switches

Switches shall be accurately positioned in accordance with the Drawings.

One switch per circuit with a maximum of three switches per outlet box shall be installed.

All single switches shall be installed with the switch vertical.

Switches shall be mounted in 100 x 50 x 50 mm outlet boxes.

Unless otherwise specified, switches adjacent to doors shall be installed on the side containing the lock. If the position of the lock is not shown on the Drawings, the position shall be verified before the switch box is installed. Switch boxes in brick or concrete walls shall be installed 150 mm from the door frame. Light switches installed in partitions or door frames shall be of the type designed for that purpose.

Switches that are exposed to the weather or are installed in damp areas shall be of the heavy duty, totally enclosed, watertight type with threaded connection for direct conduit entry and have IP65 enclosures.

39.3.3.4 Photoelectric Switches

The outside lighting of each individual building shall be controlled by photoelectric sensitive switches, with a current rating of 16 A. A by-pass switch, enabling the lights to be turned on at any time, shall be provided.

Standard control circuits are indicated in the standard assembly Drawings.

The operational level shall be factory pre-set for “ON” at a light level of approximately 54 lux and “OFF” at approximately 108 lux. Voltage variations shall not affect the operational levels.

A time delay of not less than 15 seconds shall be provided to prevent the unit from functioning due to short period changes in illumination.

The unit shall be effectively safeguarded against voltage surges by means of a suitable surge protector which shall preferably form an integral part of the unit.

39.3.3.5 On Load Isolators

Isolators shall be of the on-load type, panel or box mounted and shall have silver alloy contacts with quick make/break mechanism.

The rating shall be at least 20% in excess of the full load current of the circuit that is to be switched.

In the case of motor circuits, the isolator shall be capable of breaking the locked rotor current of the motor.

Isolators must be clearly distinguished from circuit breakers by distinctive colour of handle and clearly labelled "Isolator" and must conform with SANS 10142.

39.3.3.6 Emergency Stop Stations

The emergency stop station shall be of the push button type with twist release, approved by the Engineer.

39.3.4 Power Connections

Where sufficient space for conduit entries as well as adequate space for future conduit entries is available, conduits may be terminated directly to the gland plate on the distribution board.

Alternatively, conduits connected to distribution boards shall terminate in a common fabricated sheet steel draw-box installed in the vicinity of the switchboard. In open roof spaces this draw-box shall be placed in a roof space of not less than 900 mm clearance.

Lighting and socket outlet circuits shall be separately grouped in common conduits or metal trunking from the distribution board to the draw-box. The draw-box shall be of sheet steel with a minimum thickness of 1.6 mm and shall be fitted with a removable cover plate.

Where conduits from a distribution board run into a false ceiling space above the board, a minimum of two 25 mm and two 20 mm spare conduits shall be installed into the ceiling space immediately above the board.

Where underground cables are 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 main cable to the distribution board.

Sleeves shall be installed with a fall from inside to outside of the building to facilitate drainage. The sleeves shall be sealed with a non-hardening compound after installation of the cables to render the installation vermin-proof and waterproof.

Where an isolator, emergency stop, or starter containing an isolator is to be installed within 2 m of a motor, and cannot be installed on a wall, switchboard or other suitable place, an approved free-standing pedestal shall be provided. The pedestal shall be 1 m high and away from normal walkways, access routes, etc.

39.3.5 Conduits

39.3.5.1 General

The type of conduit shall be as specified in Section 38 – Electrical General.

Conduits may be installed as follows:

- In open roof spaces;
- Cast in concrete;
- Chased into brick walls; and
- Surface mounted against walls, concrete and steel structures etc.

Where conduits are to be installed in concrete, this shall be undertaken while the building work is still in progress. Conduits may only be surface mounted where specified or indicated on Drawings.

39.3.5.2 Other Services

Conduits may not be installed closer than 150 mm to pipes and services containing gas, steam, hot water etc., which may damage the conduits or conductors. Conduits may not be installed in contact with pipes of other service installations.

39.3.5.3 Screwed Steel Conduit

In general, heavy duty solid drawn or welded screwed steel conduit shall always be used in the wiring installations.

39.3.5.4 Plain-end Steel Conduit

As an alternative to the screwed conduit, plain-end conduit may be installed subject to the Engineer's written approval and under the following conditions:

Bending and setting of plain-end conduit shall be undertaken with special benders and apparatus manufactured for this purpose.

Plain end steel conduit shall not be used in the following instances:

a) In flameproof installations;

b) Load bearing conduit;

c) For the suspension of luminaries; and

d) Surface mounted conduit.

Plain-end conduit and associated accessories shall be manufactured of mild steel having a minimum thickness of 0.9 mm.

39.3.5.5 Galvanized Conduit

Galvanized conduit and accessories shall always be used in the following areas as a minimum requirement:

a) Damp areas;

b) Outside buildings;

c) Areas exposed to the weather;

d) All inside and outside installations within 50 km of the coast;

e) Plenum chambers containing humidifying Plant;

f) Surface mounted conduit installations in kitchens and boiler rooms; and

g) Screeds resting directly on soil.

39.3.5.6 PVC Conduit

(a) Installation Conditions

Where specified for a particular service, PVC conduits shall be installed under the following conditions:

- Insulated heat-resistant boxes shall be used for outlets to totally enclose luminaires and other fittings where excessive temperatures are likely to occur;
- Luminaires and other fittings shall not be supported by PVC conduit or conduit boxes. These fittings shall be secured to the surrounding structure in a way that is to the approval of the Engineer;
- Conduit shall be supported and fixed with stand-off saddles at a maximum spacing of 1 m. The Contractor shall supply and install all additional supports required; and
- It shall be possible to rewire a completed installation without difficulty.

PVC conduit and fittings shall not be used under the following conditions:

- Outside a building and when exposed to sunlight (unless protected, or sheltered under eaves);
- In case of mechanical load bearing;
- Where the conduit is subjected to temperatures below -10°C or above 70°C; and
- In areas where the conduit may be subject to mechanical damage.

(b) Painting of PVC Conduits

Exposed conduit may be painted with normal oil paints, but care shall be taken to ensure that the paint used does not contain any component that will have a detrimental effect on the conduit and fittings.

(c) Connecting of PVC Conduit to Metal Plant / Components

When any part of a PVC conduit system has to be connected to metal Plant or components (e.g. distribution boards, socket outlet or switch boxes, existing steel conduit system, etc.), fittings and joints manufactured specifically for this purpose shall be used. PVC conduit shall not be threaded to fit steel conduit connectors.

(d) Bends

In conduit of nominal size not exceeding 25 mm, bends may be cold bent by hand provided that the radius of the bend is greater than six times the outside diameter of the conduit, and that the angle of the bend does not exceed 90 deg. The bending procedure shall be with the correct size of bending spring. In all other cases bends shall be made with the use of accessories that are introduced into the conduit run.

(e) Adhesive Joints

All adhesive joints shall be made in a clean dry area. The surfaces of all components to be bonded shall be dry and clean.

The joint shall be made immediately after the application of the adhesive by pushing the prepared parts squarely together with a twisting motion to the full insertion depth. Care must be taken to avoid squeezing adhesive into the cableway. All excess adhesive shall be wiped off.

(f) Cutting of Conduit

Special PVC conduit cutting shears shall be used for cutting 20 mm and 25 mm conduit to the required length. For the larger sizes, a fine-tooth hacksaw may be used. Each cut end shall be square and free from burrs and loose material.

39.3.5.7 Flexible Conduit

Flexible conduit shall be used for the final connection to Plant that has to be moved frequently to enable adjustment, the connection of motors or any vibrating Plant, and for the connection of thermostats, sensors on Plant, and stoves.

Flexible conduit shall preferably be connected to the system by means of a draw-box. The flexible conduit may be connected directly to the end of a conduit if an existing draw-box is available within 2 m of the connection point.

Flexible conduit shall be of the following approved types or equal approved, provided samples are submitted to the Engineer for inspection:

a) Domestic type installations – “Spiralock” from Plastiflex (SA) (Pty) Ltd.

b) Industrial and Mining Installations – “Adaptaflex” from Reyrolle Ltd. or “Kopex”.

39.3.5.8 Termination of Conduits

(a) General

Steel conduits shall be terminated by means of either two lock nuts and a brass female bush, or by means of a conduit coupling external to the outlet box, trunking etc. and a brass male bush.

Holes shall be the correct size to accommodate bushes and conduit ends without excessive tolerance.

PVC conduits and surfix conductors shall be terminated by means of fittings approved by the manufacturer with the necessary glands, locknuts etc.

(b) Spouted Connections

Conduits shall be connected directly to draw-boxes with spouted connections. Conduits shall be screwed tightly home and no threads shall be visible.

(c) Distribution Boards, Power Skirting, etc.

Conduits shall be terminated by means of a brass female bush and two locknuts in pressed steel switchboards and distribution boxes, cable ducts, power skirting, etc. The conduit end shall only project through the entry hole to accommodate the bush and locknut.

Conduits showing exposed threads within enclosures and conduits having insufficient threads to enable the complete tightening of the locknuts and bush shall be rejected.

(d) Draw-boxes

A female bush and two locknuts shall be used to terminate conduits at draw-boxes and outlet boxes without spouts, should there be sufficient room in the box. Where there is insufficient room, a coupling, brass male bush and locknut may be used with sufficient allowance for the reduction of the internal diameter by the male bush.

39.3.5.9 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 completely down to prevent damage to the thread on the screw.

39.3.5.10 Conduit Ends

Conduit ends shall be cut at right angles to ensure that ends butt squarely at joints. Threads shall not be visible at joints and connections except at running joints. The total length of the thread on the two conduit ends shall not exceed the length of the coupling.

All exposed threads shall be properly painted with a zinc chromate primer.

(a) Joints

All conduit ends shall be reamed and all joints tightly screwed. Only approved couplings shall be used. Running joints with long threads shall be provided to ensure a strong mechanical and a continuous electrical joint.

(b) Draw-in boxes

Accessible draw-in boxes shall be provided so that wires may be easily drawn in after the conduit system is completed. They shall be installed every 20 metres in straight runs and after bends.

(c) Outlet Boxes and Accessories

Conduit outlet boxes shall be hot dip galvanized. Conduit ends shall be fitted with brass bushes with rounded mouth and under-cut threads so that the bushes can be screwed home.

All conduit fittings, boxes and accessories shall be screwed to receive the conduits. Conduit shall be fixed to socket outlets and switches by means of galvanized locknuts and female bushes or by means of coupling and male bushes.

(d) Finish

All joints shall be painted with red lead to prevent rusting in damp areas, areas within 50 km of the coast and in cases where the Installation is exposed to the weather for any length of time. Where the galvanizing or black enamel paint has been damaged, the area shall first be cleaned and a coat of zinc chromate primer applied. The final coat of enamel or galvanized paint shall only be applied after the undercoat has completely dried.

39.3.5.11 Conduit Installation

(a) General Conduit Installation Requirements

It is the responsibility of the Contractor to ensure that all outlet boxes are correctly positioned for the specified purpose.

Draw-boxes shall not be installed in positions where they will be inaccessible after completion of the installation. Draw-boxes shall be installed in positions subject to the approval of the Engineer and shall be indicated on the “as-built” drawings.

Galvanized steel draw-wires (0,9 mm dia) 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.

Prior to and during installation conducts shall be kept clean and dry. Open ends shall be plugged with stoppers (Paper, PVC etc. not allowed).

Draw-boxes shall be installed at maximum intervals of 20 m in straight runs.

Excess holes in draw-boxes or other conduit accessories shall be securely blanked off by means of brass plugs.

No facebrick or other finished surfaces may be chased without the permission of the Engineer.

Mechanical and electrical continuity shall be maintained throughout the conduit installation.

(b) Conduit for Telephone and other Systems

Where conduit is used for services other than electrical e.g. telephones, intercoms, fire alarms etc., the methods of installation as previously specified shall also apply with the following additions:

- The telephone conduit system shall comply with the requirements of the Telecommunications Authority and shall be 25 mm O/D minimum unless otherwise specified;
- Galvanized draw wires shall be left in all conduits; and
- All protruding conduits outside the building shall be terminated into a 50 x 100 mm draw box.

(c) Installation of Conduit in Concrete

Deep type conduit boxes in slabs and rear entry concrete boxes in hollow block construction shall be used.

Conduits set in concrete slabs or beams shall be firmly fixed in position before concrete is cast.

Conduit shall be installed as close to the neutral axis of the beam, slab or column as possible.

Where groups of conduits are brought to distribution board positions, the conduits shall be fixed with spacers between them equal to at least one conduit diameter. Conduits in floor slabs shall be run wholly in the concrete and not in the soil.

All conduit and accessories shall be efficiently cleaned out to remove all traces of condensation before wires are drawn.

Partially completed runs and open ends shall be effectively plugged to prevent the ingress of dirt or moisture while work is not in progress or when concrete is being cast.

All conduits shall be covered by at least 25 mm of concrete. A minimum distance of twice the outside diameter of the conduit shall be allowed between adjacent conduits in screeds. Conduits shall be fixed to the slab at intervals not exceeding 2 m before the slab is screeded.

Elbows for conduits of 32 mm diameter and smaller and sharp bends shall not be permitted in cast concrete structures.

Conduits will not be allowed in concrete floor slabs of boiler rooms (or boiler houses), laundries or other damp areas. All socket outlets and three-phase outlets in damp areas shall be supplied from above with galvanized conduit and accessories.

Conduits shall not be installed across expansion joints. Where this is unavoidable a conduit expansion joint shall be provided for the approval of the Engineer. The expansion draw box shall

be installed adjacent to the expansion joint. A conduit sleeve, one size larger than that specified for the circuit, shall be provided on the side of the draw box nearest to the joint. 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. The circuit conduit passing through the sleeve shall terminate 40 mm inside the draw box and the conduit ends shall be fitted with a brass bush. The gap be sealed with silicon sealer to prevent the ingress of wet cement.

All outlet and draw boxes shall be firmly fixed to the shuttering. Wire fixings will not be accepted in the off-shutter concrete finishes. All boxes shall be tightly packed with wet paper before fixing to the shuttering.

Within two days of removal of the shuttering, all draw boxes shall be inspected and cleaned and draw wires shall be installed. Should there be draw boxes or conduits that are blocked or have been omitted, alternative arrangements shall immediately be made by the Contractor, subject to these alternative methods routes being to the approval of the Engineer's representative.

(d) Conduits Built into Walls

The Contractor shall co-ordinate such activities with the Principal Contractor since no cutting of plastered walls will be allowed.

The chasing of walls for the installation of conduits will only be allowed under the following conditions:

- Face brick walls may not be chased;
- Brickwork already plastered may only be chased with the written approval of the Engineer;
- The Contractor shall be responsible for all chasing and fixing of conduits and outlet boxes; and
- The minimum plaster cover over conduits shall be 20 mm.

(e) Surface Installations

All conduits shall be installed horizontally or vertically as determined by the route and all measures shall be taken to ensure a neat installation.

All surface mounted conduits shall be securely mounted to steelwork, brick, concrete or timber surfaces by means of approved galvanized steel saddles, of the stand-off type with all screws and nuts galvanized.

Conduits shall be secured within 150 mm before and after each 90° bend.

Where an offset is required at conduit terminations or crossovers, the conduit shall be saddled at the offset.

Crossovers of conduits shall be in purpose-made boxes.

(f) Conduit in Roof Spaces

In open spaces (no ceiling) conduits shall be run along the wall plates and the rafters. The installation of conduits suspended between rafters will not be acceptable.

Conduit in roof spaces shall be installed parallel or at right angles to the roof members and shall be secured at intervals not exceeding 1.5 m by means of saddles screwed to the roof timbers.

Nails or clamp type fixings will not be permitted.

Under flat roofs in false ceilings or where there is less than 900 mm clearance, or in instances where the ceilings are insulated with glass wool or other insulating material impeding access, the conduit shall be installed in a manner which allows for wiring from below the ceilings.

Conduit runs from switchboards shall terminate in fabricated sheet steel draw-boxes installed directly above or in close proximity to the boards. Spare conduits covering the total number of spare ways on switchboards, shall be provided between the boards and the roof draw-box.

Only approved types of fixings and round-head screws shall be used when fixing saddles, switches, plugs, etc., to walls.

39.4 TRUNKING AND POWER SKIRTING

39.4.1 Responsibility of the Contractor

The Contractor shall supply and install all wiring channels and power skirtings as specified for the installation including the necessary supports, hangers, fixing materials, bends, angles, junctions, T-pieces, etc.

39.4.2 Wiring Channels (Trunking)

All trunking shall be hot dip galvanized or galvanized sheet steel and of a type approved by the Engineer with galvanized steel clip-on covers.

Trunking shall be completely vermin-proof, with all ends and corner fillets properly closed off.

All trunking shall be suitably and adequately fixed to supporting surfaces by means of plated bolts and nuts, or galvanized screws into drilled and plugged holes. Trunking shall not be welded to machinery, pipework, chuting or steelwork.

Cut edges of trunking shall be properly painted with zinc chromate primer paint to the approval of the Engineer.

Trunking may not be used as an earth continuity conductor and separate bare stranded copper conductors of appropriate cross-section shall be run in all trunking for earthing.

Circuits shall be segregated within the trunking into the following categories:

a) Low voltage mains circuits;

b) Extra low voltage and telecommunication circuits not directly on mains supply; and

c) Fire alarm circuits.

All trunking shall be divided into three compartments where the above categories are used.

For reasons of security and safety, fire alarm circuits shall be segregated from each other as well as from any other wiring.

Conduit connections shall be terminated by means of two locknuts and a brass female bush. Where the trunking is wide enough, conduit connections may be made by means of a conduit box and hole through the back or side of the channel. All holes through which conductors pass shall be fitted with bushes or grommets or shall be sleeved.

39.4.3 Power Skirting

Two or three compartment power skirting as scheduled shall be supplied and installed in accordance with the layouts and as indicated on the Drawings.

The top compartment shall be used for lighting and small power wiring, the bottom compartments shall be for telephone and other services.

The power skirting may be manufactured from sheet steel or aluminium in approximately 2.5 m lengths and shall be of a type approved by the Engineer. A sample length shall be provided for inspection before any orders are placed.

Factory-made end covers shall be installed at the ends of all runs of power skirting. All internal and external bends or offsets shall be factory-made and shall be installed to provide a neat and workmanlike appearance.

Steel power skirting shall be painted in a colour as specified by the Architect.

Standard 16 A, 3-pin flush switched socket outlets shall be supplied and installed in the positions indicated on the Drawings.

Conduits for the circuit wiring to the power skirting shall be installed in the floor slab and shall terminate in flush conduit boxes, behind the power skirting and installed to match the height of the power, telephone and other service compartments of the skirting.

The wiring shall pass through large diameter holes cut in the rear of the power skirting. The holes shall be suitably bushed or trimmed to prevent damage to the wiring or cables.

Conduits feeding to the lower or telephone compartment shall be terminated in boxes in the floor slab immediately below the power skirting, with suitable bushed or trimmed openings being provided through the bottom of the power skirting duct for the cables to pass through.

Each section of power skirting shall be earthed and bonded with a 2,5 mm² earth conductor. No cutting by hand of any power skirting on site shall be accepted.

All conductors shall be installed in power skirting with a loop allowing sufficient slack for additional outlets. Power skirting shall be mounted 10 mm above the finished floor to allow for floor finishes later.

Factory made end covers shall be installed at the ends of all runs of power skirting. All internal and external bends or offsets shall be factory made.

Power skirting and covers shall be supplied to site with a protective plastic covering which shall remain in position till completion to protect the finish.

39.5 LUMINAIRES

All luminaires required shall be positioned as shown on the Drawings.

Luminaires, associated Plant 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. Luminaires shall be delivered and installed with all other Plant required for the satisfactory operation of the luminaire. Alternative luminaires offered shall be submitted for the Engineer's approval.

Tenders shall be accompanied by full descriptive information of the luminaires offered. Photometric data, i.e. polar curves and co-efficient of utilization certified by the SABS shall be submitted with tenders for all luminaires offered.

The layout as shown on the Drawings shall generally be adhered to but any discrepancies or clashes with structural or other features shall be referred to the Engineer and verified on Site, before commencing the installation.

All luminaires shall be equipped with an earth terminal and shall be effectively earthed.

The following standard colour code shall be observed in the wiring of lighting circuits:

- Red : Line conductor
- Black : Neutral conductor
- Green : Earth conductor
- Grey : Return conductor from switches
- Yellow : Interconnecting conductors between 2-way switches

The distribution of discharge lamps over the 3 phases shall be arranged to avoid stroboscopic effects. Loads shall be evenly distributed over the 3 phases at every distribution board.

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

Luminaires shall be completely wired internally. Conductors shall be protected with grommets where they pass through holes in the body.

The wiring shall be totally enclosed to prevent any possible contact with live components while changing lamps.

The conductor insulation shall be rated to withstand the temperature inside the luminaire body without deterioration.

The wiring shall terminate on a suitable terminal block. There shall be no joints in the internal wiring.

An earth terminal, welded to the luminaire body, shall be provided. To ensure good earth continuity the earth terminal shall not be spray painted. The earth conductor shall be connected to this terminal by means of a crimped lug.

Emergency lighting shall be provided by a battery back-up, the battery back-up time shall be three hours.

All the emergency luminaries shall be marked as such (sticker with “Emergency” written in red on white background).

Floodlights luminaries with a minimum ingress protection of IP65 shall be used unless otherwise specified by the Electrical Engineer.

39.6 LIGHTING SMALL POWER DISTRIBUTION BOARDS

Distribution boards shall be constructed in such a way that it will be capable of withstanding all mechanical, electrical and thermal stresses as well as the effects of dust ingress and humidity that will be encountered during normal operation. The minimum thickness for the plate steel shall be 2 mm. The distribution boards located outdoor shall be rated IP65 and those located indoors shall be rated IP55 in accordance IEC60529. Distribution boards located in hazardous locations shall conform to the requirements of SANS 10108. Cubicle doors shall be positively drawn closed onto seals by means of padlock-lockable lever operated catches.

Each distribution board shall be provided with an internal Plant cover plate in accordance with SANS 10142-1. The cover plates shall not be used to keep components in the position. The cover plates shall be provided with hinges for the opening / closing and shall be provided with a square key lock. The main circuit breaker shall be mounted inside the distribution board and be labelled “MAIN SWITCH” and rated in accordance with SANS 10142-1. The bus bars shall be colour coded i.e. black used for the neutral conductor and green / yellow for the earth. The minimum phase-phase and phase-earth clearances shall be 25 mm. Components in the boards shall be so arranged that diagnostic checks can safely carried out with electrical Plant energized. Components shall be mounted on a backplate with DIN rails. No holes shall be drilled through the distribution board as this will jeopardize the IP rating.

Finishing colour of 230/400V boards shall be orange to SANS 1091. Cable entry shall be from the top and bottom only. No side or back entries shall be accepted.

The distribution board circuit design shall be such that the load distribution between the phases is even (within 10%).

39.7 EARTHING AND LIGHTNING PROTECTION

39.7.1 General

The earthing and lightning protection systems shall meet the requirements of the acts or the legislative requirements applicable to the place of installation.

The earthing and lightning protection systems shall comply with the fundamental safety requirements of Clause 5 of SANS 10142-1.

The earthing and lightning protection systems shall as a minimum be designed, constructed and tested in accordance with the requirements of SANS 10313 and a certificate shall be issued to this effect.

All components and electric conductors fitted to the ASSEMBLY shall be certified as safe by means of valid RCC certificates in accordance with SANS 10313 or identified by a SABS ‘Mark of Approved Performance’.

Each completed earthing and lightning protection systems shall be certified in terms of the requirements of SANS 10313 and this specification by a person who is competent to express an opinion on the safety and functionality of the earthing and lightning protection systems.

The earthing and lightning protection systems shall be designed and installed according to the requirements of this Section and all parts of the latest revision of the following specifications at the time of tender:

a) SANS 725: IEEE guide for safety in AC substation grounding;

b) SANS 1063: Earth rods, couplers and connections;

c) SANS 10225: The design and construction of lighting masts;

d) SANS 10292: Earthing of low-voltage (LV) distribution systems;

e) SANS 10142 All Parts: The Wiring of Premises;

f) SANS 10199: The design and installation of earth electrodes;

g) SANS 10313: Protection against lightning – Physical damage to structures and life hazard;

h) SANS 61643: All Parts: Low-voltages surge protection devices;

i) SANS 62305: All Parts Code of Practice for the Protection against lightning;

j) SANS 62561: Code of Practice for Lightning Protection System Components (LPSC); and

k) NRS 012: Cable terminations and live conductors within air-insulated enclosures (insulation co-ordination) for rated ac. voltages of 7,2 kV and up to and including 36 kV.

A soil resistivity survey shall be performed at each Site location in order to establish the requirements for a suitable earthing installation of sufficiently low impedance and adequate equalisation of earth potential over the installation.

The earthing of the entire electrical installation shall be installed by the Contractor and shall consist of electrical earthing, instrument earthing and lightning protection. Each earthing system shall be installed in accordance with the requirements laid down and as directed by the Engineer and shall be connected to 1 main earth bar as shown on the Drawings. The main earth bar shall be connected to a main earth electrode system.

The Contractor shall carry out all the earth resistance testing as specified in accordance with the Engineer's requirements. All additional earthing requirements resulting from the tests shall be installed by the Contractor.

The Contractor shall be required to demonstrate their competency to interpret the requirements of SANS 62305-2 to perform a risk analysis by submitting such an analysis for the installation.

For substation earthing, the ground potential rise (GPR) shall be determined in accordance with the requirements of IEEE-80.

A proposed layout of the earthing system shall be submitted to the Engineer for approval.

39.7.2 Main Earth Electrode System

The whole installation is to be earthed efficiently and effectively, so that the resistance to earth from any point does not exceed the value laid down in the operative wiring regulations. The whole installation must be effectively bonded as far as the main switchgear.

Earth terminations into the general mass of ground shall be installed as early as possible in the building programme and the onus is on the Contractor to arrange this to avoid later disturbance of completed construction. Before proceeding, however, the attention of the Engineer is to be drawn to the exact proposals and approval obtained.

All earthing connections shall be by means of exothermic welds. Self-tapping screws are not acceptable as a method of fixing earth terminations.

The earth electrode system shall consist of a completely buried trench earth of 70 mm² stranded copper cable and earthing rods as shown on the Drawings.

The depth of the trench earth shall be 500 mm minimum below finished grade. All trench earths shall be interconnected and connected to earthing rods as shown on the Drawings.

A sufficient number of electrodes shall be driven at each selected location to obtain a system earthing resistance of one (1) ohm or less. If more than one rod is required at a location, the rods shall be spaced 3 m apart.

The earth electrode system shall be connected to the main earth bar with un-insulated 70 mm² stranded copper conductor.

The Contractor shall allow for testing the earth resistivity at termination points and the earth resistance of the main earth electrodes in the presence of the Engineer. The earth resistance for each electrode shall be less than 1 ohm. Earth resistivity tests are to be submitted timeously to the Engineer to allow for revision of earth termination where required.

For each location an earth resistivity test, design report and earthing certificate shall be issued by the Contractor on completion of the installation. This is a requirement for hand-over and the hand-over certificate shall not be issued until the engineer is satisfied with these documents.

39.7.3 Main Earth Bar

Two suitably sized, but not smaller than 70 mm² bare copper earth conductors shall be run from each earth mat to an earth bar to be fixed, with insulators, inside the applicable plant room cable trench or against the wall. The earth bar in the main low voltage distribution board, on the transformer and on the medium voltage switchgear shall be connected to the earth bar in the cable trench with separate 70 mm² links, the ends of which shall be suitably and properly lugged and bolted.

One main earth bar shall be installed per area, in the location, as shown on the Drawings. The earth bar shall be a 12.5 x 50 x 900 mm tinned copper earth bar mounted to the wall by three substantial stand-off spacers and bolted to the wall with brass bolts.

Earthing and bonding conductors shall be hard drawn green PVC insulated stranded copper conductors or rectangular solid copper straps. All earth conductors shall be bolted to the main earth bar or to earth and neutral busbars by means of 10 mm diameter bras bolts, nuts and locknuts. Each earth conductor shall be clearly labelled, for identification purposes, with durable labels or tags.

The ends of stranded copper conductors shall be fitted with lugs. The lugs shall be fixed by means of a hexagonal compression crimping tool, brazing or silver soldering. The ends of rectangular solid copper straps shall be tinned before being connected to busbars or earthing points.

No joints shall be allowed in any earthing and bonding conductor.

All earthing straps shall be run in one continuous length but shall not be bent or formed in any way that necessitates hammering or severe distortion. If multiple straps are used, they shall be clamped together and fixed at maximum 750 mm.

The following steel structures and Plant shall be bonded to the main earth bar via the Site earthing system: tanks, vessels, heat exchangers, pipeways, buildings, fences, transformers, switchgear, motor control centres, cable racks, motors, lightning arrestors, lightning panelboards, lightning masts and other items requiring earthing.

Lead sheath, continuous metallic sheath, wire armour or armour tape of cables shall be bonded to the frame of Plant at each end of the cable. All properly prepared cable glands shall provide an acceptable earth bond on cables. All Plant frames shall be bonded to the earthing system.

39.7.4 Instrument Earthing

Separate instrument earth bars will be provided at each PLC, in the Server Room, Patch Rooms, and other strategic areas. All instrument earthing shall be connected to this earth bar only. Instruments shall not be earthed at the instrument in the field.

The instrument earth bar shall be connected to the main earth bar via a surge gap arrestor as shown on the Drawings.

39.7.5 Electrical Earthing

The earth bar in each switchboard shall be connected to the main earth bar by a 70 mm² un-insulated stranded copper conductor and bolted to the earth bar by an 8 mm brass bolt.

All auxiliary panels smaller than 25 kW shall be earthed to the earth bar by 16 mm² un-insulated stranded copper conductor and bolted to the earth bar by an 8 mm brass bolt.

39.7.6 Lightning Protection of Buildings

The lighting protection system shall fully comply with the latest revisions of SANS 10313 and SANS 62305.

The test links shall be installed in such a manner that it will always be accessible.

Air finials, earth conductor and down conductor installations shall be as per SANS Code of Practice 10313.

Concrete reinforcing shall NOT be used as a natural down conductor. A dedicated down conductor cable shall be installed within the columns secured with suitable clamps and flush fittings.

Down conductors shall be of a standard copper or aluminium down conductor installation type, installed with the correct brackets and saddles for that specific conductor. The down conductor shall take a vertical path down from the conductor without any bends or kinks to the earth electrode. The conductor shall be supported at 1 m intervals by copper saddles and brass screws down the length of the building. The saddles shall be fixed by drilling the masonry and installing plastic plugs.

The earth electrode system shall have an earthing resistance of 1 ohm or less. The earth electrode system shall be connected to the main earth bar as shown on the Drawings.

Wherever possible the lightning conductor shall be connected to all local earth points (e.g. metal roofs, gutters, etc.).

Television aerials shall be earthed as above but only aluminium or aluminium alloys may be used for the down conductor, jointing and supporting materials and earth electrode.

All down conductors shall be routed outside the building and away from flammable material.

A test point shall be fitted on each down conductor at the earth termination connection, in the case of natural down conductors the test points shall be combined with foundation earth electrodes.

The Contractor shall arrange for testing the earth resistance of the lightning protection electrodes in the presence of the Engineer. Two copies of the test certificate containing these test results shall be submitted to the Engineer.

A certified test report shall be submitted to the Engineer after completion of:

- The installation of the ground earth system with the earth resistance shown for each earthing point; and
- The complete lightning protection system with all test links in position.

39.8 MEDIUM VOLTAGE SWITCHGEAR

39.8.1 Standards

All materials and Plant provided under this Section shall comply with the latest revision of the following standards:

EN 50181	:	Plug in bushings, 1 kV to 36 kV from 250 A 1.25 kV
IEC 60044 (all parts)	:	Instrument transformers
IEC 60050 – 441	:	Electrical Vocabulary, Switchgear, control, fuses
IEC 60059	:	IEC standard current ratings
IEC 60282 -1	:	High voltage fuses part 1, current limiting
IEC 60529	:	Degrees of protection for enclosures
IEC 60617	:	Graphical symbols for diagrams
IEC 60815 – 4-17	:	EMC, testing and measurement techniques
IEC 62271 (all parts)	:	HV switchgear and control (excl. parts 2, 104, 203, 204)

Switchgear and all the auxiliary Plant shall be of approved design and shall be manufactured to the highest standards of workmanship.

All Plant shall be designed and manufactured to obviate danger or hazard to the safety of personnel.

39.8.2 Standardisation of Plant

Similar Plant that has been designed to perform the same functions under similar conditions and is supplied under the same contract shall be identical in all respects and it shall be possible to exchange similar items. This shall also apply where similar Plant is purchased at a later date to extend, replace or supplement Plant already in service.

39.8.3 Finishes for Material and Plant

On all switchgear supplied, anti-corrosion protection shall be provided in accordance with Section 37 – Painting and Corrosion Protection.

39.8.3.1 Painting Ungalvanized Steelwork

a) All surfaces shall be satisfactorily cleaned in accordance with a method detailed in SANS 064.

b) The clean steelwork shall be painted with a zinc chromate primer that complies with SANS 679, type 1. The dry thickness of the film shall be at least 25 microns.

c) The steelwork shall be finished off with two coats of high gloss enamel paint that complies with SANS 630. When dry the paint film shall be at least 70 microns thick when measured using a method in accordance with SANS ISO 2808.

d) The exterior of all switchgear shall have a colour specified in the contract detailed specification from SANS 1091.

e) The interior of all panels including doors, removable panels and busbar chambers shall be finished in white.

f) Paintwork that gets damaged during delivery or installation shall be repaired and made good using a method approved by the Engineer.

39.8.3.2 Powder Coating

a) The same requirements stated under 3.1 above shall, where applicable, apply to all finishes that make use of a powder coating process.

b) The requirements of SANS 1274 type 1 shall be complied with.

39.8.3.3 Galvanized Steelwork

a) All steelwork shall be neatly finished off to remove roughness and burrs before galvanizing is carried out. Bending, forming, punching, drilling, welding and machining shall have been completed.

b) All galvanizing shall be carried out using the hot-dip method and shall comply with SANS 763. All repairs done on Site shall also comply with this Section.

c) Cadmium or other forms of plated corrosion protection shall not be accepted where hot-dip galvanizing has been specified.

d) All bolts, nuts and washers used on galvanized steelwork shall also be galvanized to the same specification.

e) If galvanized steel is painted, it shall be cleaned and the following paint applied.

f) Primer - Calcium plumbate to SANS 912.

g) Undercoat - Comply with SANS 681, type 2.

h) Top Coat - Comply with SANS 630, grade 1.

39.8.4 General Requirements

a) All circuit breakers shall be of the vacuum or suplhurhexa-fluoride type. Bulk oil or minimum oil breakers shall not be acceptable. The circuit breakers shall be horizontal or vertical isolating and the carriage shall withdraw horizontally from the housing with minimum effort.

b) The circuit breakers shall be 3 pole and suitable for operation indoors in a mining environment.

c) The rated frequency shall be 50 H_z and the phase rotation anti-clockwise: red-yellow-blue-red.

d) The fault rating, voltage rating and impulse withstand rating shall comply with the values stated in the detailed specification.

e) Switchgear that is in every respect similar to that provided shall have been type tested by a recognised test authority for impulse withstand and short circuit to the values specified. Copies of type test certificates, and routine tests, shall be submitted.

f) Comprehensive documentation shall be provided for all switchgear supplied to for every contract. This shall include drawings, installation and commissioning instructions, operating and maintenance instructions, protective relay manuals, complete spares list, repair specifications and tests. Training manuals and Plant shall also be available. All documentation shall comply with the Engineer's requirements. Refer to Section 48 – Tests on Completion.

39.8.5 Rating of Switchgear

39.8.5.1 Voltage Rating

The switchgear shall be suitable for safe operation on the specified system during all the operating conditions specified in Section 38 – Electrical General.

There shall be no audible corona discharge under working conditions. This requirement shall be taken to be complied with only if the audible corona extinction voltage, phase to earth, or phase to phase, is not less than 125% of nominal system voltage. Compliance may be conceded if it can be shown that any discharge below the specified level take place at points remote from all dielectric materials and cannot cause their deterioration.

39.8.5.2 Fault Capacity

The switchgear shall have the fault current ratings at nominal system voltage specified in Section 38 – Electrical General.

Testing shall be done on an entire switch unit, complete with circuit-breaker, potential transformer and condenser bushings where applicable, current transformers, busbars, shutters, cable boxes and if necessary, such parts of adjacent panels as are required to support the busbars and present a complete unit for testing.

39.8.5.3 Impulse Rating

The switchgear shall have an assigned impulse rating of not less than specified in Section 38 – Electrical General, supported by recent test certificates proving successful testing, using a standard 1/50 microsecond voltage wave, on identical units, manufactured in the factory from which an order would be executed.

Testing shall be done on an entire switch unit, complete with circuit-breaker, potential transformer and condenser bushings where, if applicable, current transformers, busbars, shutters, cable boxes and if necessary, such parts of adjacent panels as are required to support the busbars and present a complete unit for testing.

If tests are done specifically for the purpose of this enquiry, a panel of each rating shall be tested by applying impulses to the feeder side of the panel and testing all possible combinations of conditions materially affecting the distribution of impulse stresses, such as VT "In" and "Out", CB "In" - "Open" and "Closed" and "Out" etc. for all combinations between phases and to earth. If required, impulse tests shall be done in accordance with the relevant SANS, BS and IEC Specifications, as amended.

Existing certificates will be considered on their merits, subject to proof that the tested unit complied with the above requirements of test assembly.

The complete switchboard shall withstand a one-minute power frequency voltage, as specified in Section 38 – Electrical General.

Should reasonable doubt exist as to the validity of test certificates submitted, for example by virtue of modifications made to the switchgear, the Engineer may direct that a further certificate(s) be obtained on a sample unit(s) manufactured under the Contract at the expense of the Contractor. Such tests shall be carried out by a recognised testing institute and at his discretion, in the presence of the Engineer.

39.8.6 Busbars and Connections

The busbars and the circuit connections to the busbars shall have normal current ratings as specified. The busbars shall be PVC insulated throughout their length. It shall be possible to make direct panel to panel connections without interconnecting links. The joints shall be shrouded.

The busbars shall be manufactured of HDHC copper and rated in accordance with BS 159 for the maximum design load. The busbars shall be braced and supported to withstand the maximum fault current specified.

Provision shall be made for easy access to busbars and busbar joints for locating possible corona during testing, and for remaking joints if required, or replacing primary plug-in bushings. Work of this nature must be possible with the switchboard in service on the other set of busbars, and should not involve, breaking cable end boxes, removal of current transformers or current transformer chambers, or removing relay boards from the switchboard.

The use of cabled sections in busbar runs - e.g. to provide connections to bus-couplers is not acceptable without the written approval of the Engineer.

Double busbar switchgear shall be specifically designed as such and shall have access to the circuit breakers for busbar selection and racking into the busbar from one side - i.e. the front of the switchgear only.

The temperature rise of busbars, busbar joints, busbar connections and breaker plug-in contact shall not exceed the figure laid down by BS 159: when carrying rated current, due account being taken of temperature rise correction for altitude.
Tenderers shall state the extent to which they meet these requirements and shall clarify the position with the aid of drawings, if necessary.

39.8.7 Circuit Breakers

The circuit breakers may be either of the, vacuum or sulphur hexafluoride (SF-6) gas insulated type or as specified in Section 38 – Electrical General. Bulk oil or minimum oil breakers are not acceptable.

The circuit breaker shall be truck mounted and it must be possible to remove the circuit breaker bodily for inspection and adjustment. Arrangements shall be made for easy examination of the circuit breaker contacts where applicable.

Contractors shall quote separately for providing power operated racking of circuit breakers using an electric motor drive, either as an integral part of each switch unit required to be so equipped or, by using a common driving unit, which can be temporarily coupled to any circuit breaker on a switchboard for the duration of a racking operation.

In instances where frame leakage protection is installed on a switchboard the drive arm or mechanism of the power drive which is in contact with the metal work of the switchgear, must be fully insulated from earth to prevent possible shunting of the frame leakage protection.

The supply to be used for this purpose shall be the standard AC auxiliary supply. The direct current supply shall not be used for this purpose.

Where power assisted racking is offered it shall be possible to disengage the power drive, and carry out the operation manually when required, during power failure.

The breakers shall be designed for duplicate busbar operation with off-load busbar selection.

Circuit breaker control switches shall be of the pistol grip type with facilities to be pad locked. The control switches shall not close the circuit breaker unless first turned to the "open" position and shall always return to the neutral position when released.

39.8.7.1 Rating

Each complete circuit breaker shall have a rated short circuit making and breaking capacity as specified in Section 38 – Electrical General. This rating shall have been proved at a recognised testing station, and certified copies of the relevant sections of the test certificates shall be submitted with Tenders. The Engineer shall be entitled to complete test certificate should he deem it necessary to properly adjudicate a tender.

The circuit breakers together with associated contact plugs and primary connections shall have the normal current ratings specified in Section 38 – Electrical General.

The circuit breaker shall be designed to interrupt safely all currents in the range from zero to maximum fault current.

39.8.7.2 Vacuum

a) Interrupters shall be factory sealed units providing reliable arc extinction.

b) Interrupter contact material shall be chosen to give a very low current chopping level and restrike transients shall not generally occur under normal conditions.

c) It shall be possible to assess interrupter wear during routine maintenance using a simple gap gauge.

d) Mechanical life expectancy shall be at least 10 000 switching cycles at rated current for the interrupters.

39.8.7.3 Sulphur Hexafluoride (SF6)

a) Arc extinction shall take place using the SF6 puffer technique.

b) The moving contacts of the interrupters shall be operated by a fast-acting mechanism, independent of operator action.

c) The SF6 - filled interrupters shall preferably be “sealed for life”.

d) If a gas pressure monitor is provided, it shall be wired to trip the breaker at a predetermined minimum safe pressure. An indicator shall be provided to signal the low pressure condition.

39.8.7.4 Withdrawal of Circuit Breakers

a) Vertical isolation and horizontal draw out, or horizontal isolation and draw out shall both be acceptable.

b) Main circuit isolating contacts shall be made of HDHC copper with silver plated contact surfaces. They shall be self-aligning and easily replaceable.

c) Guides in the housing shall ensure that the truck may be easily and accurately installed into the housing.

d) Racking of vertically isolated breakers shall be done by an effective mechanism that is easy to operate. For horizontally isolated breakers the final truck insertion shall be done with a robust racking screw. The truck shall be fitted with suitable wheels to facilitate manoeuvring of the circuit breaker when it has been withdrawn.

e) One set of operating and racking handles shall be provided for each panel of circuit breakers provided.

f) Auxiliary circuit connections between the housing and carriage shall automatically engage and/or disengage when the truck is inserted or removed. One set of jumper connections per switchboard shall be provided for testing when a breaker is not in the service position.

g) Two spare sets of N/O and N/C auxiliary switches shall be provided on each breaker. They shall be wired to a terminal block.

h) The circuit breaker track shall make adequate connection to the main panel earth by means of a spring loaded clevis or similar device.

39.8.7.5 Closing Mechanism

a) Closing mechanisms shall be of the stored energy charged spring type providing high closing speed. Solenoid operated breakers shall preferably not be provided.

b) Charging of the spring shall be either manual using multiple strokes of the operating hand or by a small motor. It shall be possible to charge the spring with the breaker open or closed. Motor wound charging shall generally be provided when remote operation is required.

c) Manual spring release for closing shall not be permitted; an electrical release shall be provided.

d) The closing mechanism shall be designed to prevent tripping from any other than the fully closed position.

e) Clearly labelled mechanical interlocks shall be provided to prevent the following:

   i) A closed circuit breaker from being withdrawn from or inserted into the service position;

ii) Tripping by attempted isolation; and

iii) Closing of the circuit breaker except when correctly installed in the service position, the earth position, isolated, or when completely withdrawn.

The conditions shall preferably be controlled by a manual selector gate mechanism.

f) Mechanical indicators on the mechanism shall clearly indicate the status of the breaker, open or closed, and of the spring, charged or discharged.

39.8.7.6 Tripping of Circuit Breaker

a) Circuit breakers shall be capable of being fitted with undervoltage and shunt trip coils. Unless otherwise specified, the undervoltage coils shall operate at 110 V AC and shunt trip coils at 30 V DC.

b) When the circuit breaker is open, the trip coil circuits shall be isolated via auxiliary circuit breaker contacts.

c) A mechanical pushbutton for tripping the circuit breaker shall be provided on the front of the breaker.

d) The design of the shunt trip coils shall be such that a drop of 25% in the direct current voltage will not prevent their successful operation.

39.8.7.7 Indicating Device

A visual, positively driven mechanical indicating device shall be provided on the circuit breaker to show whether it is in the service, isolated, or earthed position, and whether it is closed or open.

39.8.7.8 Auxiliary Switches

Auxiliary switches shall be positively driven in both directions and shall be readily accessible for maintenance and shall be properly adjusted where necessary.

All auxiliary switches necessary for the successful operation of the switchgear shall be provided. A minimum of two additional spare auxiliary contacts shall be provided per circuit breaker, which shall be wired to the terminals in the control cable boxes.

39.8.7.9 Earthing Device for Circuit Breaker Plant

Means shall be provided on all incoming as well as all outgoing feeder panels for integral earthing of the cable circuits through the respective circuit breakers. In addition, means shall be provided for integral earthing of the busbars through the "bus coupler" or "bus-sectionaliser" circuit breaker.

In the case of double busbar switchgear, independent means shall be provided to earth any one of the two busbars at any given time through the busbar coupler circuit breaker. Contractors are required to clearly indicate with their tenders, how these above requirements are met.

Should separate earthing panels or earthing trucks be required for such cable or busbar earthing, one complete panel and or circuit breaker earthing truck of each type shall be provided and allowed for as integral part of this tender.

The main earth bar used for earthing the feeder or the busbars shall be of copper having an adequate cross-sectional area. In the case of boards intended for frame leakage protection, the main earth bar shall be insulated from the switchgear frame on 'stand-off' type insulators. A minimum clearance in air of 15 mm shall be maintained between the main earth bar and the switchgear frame or panel earthing. In all other cases the insulators may be omitted.

39.8.7.10 Isolating Contacts for Secondary Circuits

The connections in the secondary circuits between the fixed and moving portions of the Plant shall be by means of self-aligning contacts. Robust guide pins or other approved guides shall engage before the contacts.

Quality and design are considered vital to ensure faultless contact.

The Contractor will be required to submit samples for approval before manufacture is commenced.

Circuit breaker auxiliary contacts for functions common to the various panel types specified shall be wired to secondary isolating contacts in the same relative positions on all panel types specified (interchangeability). All such auxiliary contacts shall be of the spring-loaded type with sufficient travel and shall have a sweeping contact action. Plug in type of contacts are subject to the written approval of the Engineer.

Means shall be provided for coupling the secondary circuits on the fixed and moving portions of the Plant when the circuit breaker is racked out. (These shall have positive locating devices to prevent any misalignment at insertion). If this requires separate Plant, one complete such set of Plant shall be supplied with each complete switchboard.

39.8.7.11 Interchangeability

All the circuit breakers of the same current rating shall be identical and fully interchangeable.

39.8.7.12 Positions Stops and Guide Rails

Immediately prior to racking in, positive stops shall be engaged to locate the circuit breaker in the correct position relative to the busbar selection guides or other approved means shall be provided to ensure accurate entry into the guides.

A positive stop shall be provided to ensure correct location without danger of "over-run" in the "racked in" position.

Guide rails shall be provided at the base to ensure smooth entry of the circuit breaker carriage into the housing.

39.8.7.13 Interlocks and Safety Shutters

In addition to any other interlocks that the Contractor may consider necessary the following mechanical interlocks shall be provided:

a) To prevent the circuit breaker being withdrawn from or inserted into the isolating contacts when it is closed;

b) To prevent the circuit breaker being closed unless it is correctly located in the service, earth, or isolated positions or unless it is withdrawn from the fixed portions of the Plant;

c) To prevent the circuit breaker being closed in the service position without completing the auxiliary circuits between the fixed and moving portions;

d) To prevent accidental contact with live parts; and

e) To prevent access to the high-voltage potential transformer fuses unless the transformer has been fully isolated.

Automatic steel shutters capable of being pad-locked in the closed positions shall cover all stationary isolating contacts when a circuit-breaker is isolated. It shall be possible to open the shutters when the carriage is withdrawn for testing.

All safety shutters shall be clearly and permanently labelled with letters of the largest possible size, the label providing information of the circuit or busbars screened off by the shutters. Busbar shutters shall be clearly labelled - "Front BB" or "Bottom BB" or "Back BB" or "Top BB" in large white letters. Feeder shutters shall be similarly labelled - "Feeder".

Shutters covering each of the above groups, shall be capable of being independently unlocked and opened as a group for testing purposes, in accordance with BS 5227 and shall be painted the specified red for busbar shutters and lemon yellow for cable spout shutters.

When the circuit breaker carriage is either withdrawn, or raised or lowered, (depending on the design) to disconnect or make the fixed isolating contacts, substantial safety shutters shall be actuated by the circuit breaker carriage to automatically expose or cover the fixed isolating contacts.

39.8.7.14 Circuit Breaker Panels

The housing shall be of rigid seam-welded and bolted sheet steel construction providing a robust Plant. Separate compartments shall be provided for auxiliary wiring, current transformers, busbars, and relays and instruments. No rivets shall be used in the construction.

If required in Section 38 – Electrical General, provision shall be made for an angle section at the rear bottom of the housing on which chequer plates covering the cable ducts can rest.

39.8.7.15 Cable Boxes

All cable boxes shall be fully accessible and shall be fitted such that working space is available to the satisfaction of the Engineer.

Each circuit breaker cubicle shall be provided with a cable end box suitable to accommodate the cables specified.

Where single-core cables pass through the boxes, non-magnetic materials shall be used to reduce heating. The diameter of the hole in the cable box gland plate shall be bored at least 10 mm larger than the internal diameter of the cable gland used.

The size and type of cable for each switchgear panel shall be ascertained prior to manufacture and the size and type of the cable box shall depend on the choice of cable; PILC or XLPE.

For XLPE cable suitable tinned lugs, bolts, nuts and washers shall be provided for the cable sizes specified.

For PILC cable suitable cast iron or steel fabricated cable end boxes shall be provided, suitable for the cable sizes specified, with all the necessary lugs, bolts, nuts and washers supplied.

Approved heat shrink type cable terminations may be provided. Wooden clamping blocks shall be included that support the cables inside the switchgear panel and below the cable termination.

39.8.8 Current Transformers (CT's)

Current transformers shall comply with the requirements of BS 3938.

CT's shall be capable of operating all the relays, instruments, transducers and other devices connected in circuit.

CT's shall withstand the full through fault of the circuit breaker that they are installed in.

All CT connections shall be wired to an approved test block on the instrument panel. Where dual or multiple ratio CT's are used, all the secondary connections shall be terminated on a clearly labelled terminal block. The label shall provide instructions on selecting the required ratio.

CT's shall be fitted with rating plates with markings in accordance with BS 3938. The rating plate shall be located on the CT where it is easy to read after the CT has been installed.

Where the CT's are to be connected to remote metering, the secondaries shall be wired to terminal blocks at the rear of the panel. The secondary leads shall be shorted out at the terminals and a label shall be installed there to warn against open circuiting CT's.

Unless Section 38 – Electrical General, stipulates alternative requirements, classes of CT's shall be as follows:

- For protective relays, local indicating ammeters and power factor indicators: Class 10P 15;
- For kWh meters, kW and kVA meters and recording instruments: Class 0,5; and
- For differential protection: Class X. Where class X CT's are specified, full magnetising curves shall be provided for each CT.

39.8.9 Voltage Transformers (VT's)

Unless otherwise specified, VT's shall be 3 phase with the secondary voltage 110 volts AC. The centre phase (white or yellow) shall be permanently connected to earth.

VT's shall be continuously rated to supply all meters, relays, indicating lights, battery chargers and other loads connected. The minimum output shall be 200 VA.
VT's shall preferably be of the epoxy resin insulated type and shall be withdrawable. When withdrawn the VT spouts shall automatically operate safety shutters to close off the plug in connectors. Isolation shall be possible without interruption of the main circuit. Provision shall be made for locking the VT in the "operation" or "transportation" mode.

VT's shall be busbar or cable connected as specified. Where VT's are fitted to switchboards equipped with a bus coupler and two VT's are installed, change-over circuitry shall be provided to

ensure that they are not connected in parallel. If one VT is taken out of service, the other shall automatically be switched into service.

High voltage and low voltage fuses shall be provided for each VT. Access to the HV fuses shall only be possible when the VT is withdrawn.

VT 110 volt circuits shall be wired to an approved test block on the instrument panel. If remote metering is required, the 110 V circuit shall be wired through to terminal blocks at the back of the panel.

Unless otherwise specified, class 1 accuracy VT's shall be provided.

39.8.10 Control Switches and Indicating Lamps

The control switches and indicating lights shall be mounted at a convenient height at the front of each panel, preferably on a hinged door. Full details of the requirements are provided in the detailed Specification.

Unless otherwise specified, each circuit breaker shall have a remote closing selector. For remote opening and closing, a fully equipped panel shall be provided in the substation, but at a safe distance from the switchgear. Open and closed indication shall also be provided on this panel. Local opening and closing shall be carried out at the switchgear and shall generally only be used with the circuit breaker in test mode. Where specified a plug-in pendant type control shall be provided so that operators may control switching from a distance of 6 meters.

The open and close function shall be incorporated in a single switch assembly fitted with a pistol grip opening handle. The switch shall spring return to the neutral vertical position. The switch shall be mechanically interlocked to ensure that it must be turned to the "trip" position before a "close" operation is executed. The switch shall be provided with a facility to lock it to prevent operation.

All switchgear "trip" controls shall operate whether remote or local has been selected.

Indicating lamps or any other standing supply shall not be permanently connected to the tripping battery supply. Preferably the 110 V AC from the VT or an alternative supply shall be used.

All indicating lamps, pushbuttons, selector switches or other manual pilot devices used for man-machine dialogues shall be from suppliers that are well established in the industry. Spare components, lamps, lenses and accessories shall be readily available from stock. 30.5 mm fixings are preferred.

39.8.11 Anti-condensation Heaters

200 watt 230 volt heaters shall be provided and installed in each switchgear panel to prevent a build-up of moisture in the busbar and CT chambers.

The heaters shall be controlled by a clearly identified on/off switch located on the front of one of the panels.

39.8.12 Labelling

Each circuit breaker shall be identified with a panel number and unique designation that describes the circuit to which it is connected. The circuit name shall in every respect correspond to the designation used for the circuit on the relevant Drawings.

The labels shall be engraved onto material such as trafolite and the letters shall be at least 12 mm high. The labels shall be attached with screws; adhesives are not acceptable. A similar label shall be attached at the back of the switchgear.

Where a complete panel of switchgear is provided for a substation, a label shall be mounted at the top of the panel, in the centre, with the name of the substation engraved in letters at least 50 mm high.

All labels, warning notices and rating plates shall be in English.

39.8.13 Control, Protection and Auxiliary Wiring

All panel wiring for these circuits shall be segregated as far as is possible in high voltage compartments.

The minimum wire size shall be 2.5 mm^2 cross sectional area and shall be made up of no less than 7 strands. The wire shall be PVC insulated.

All wires shall be terminated with suitable lugs and with wire numbers identical to those used on the relevant schematic diagrams. Terminal blocks and terminal strips shall be readily accessible.

Wiring that connects to external pilot cables, control cables etc. shall be terminated in a separate terminal box at the back of the switchgear. This terminal box shall be fitted with a gland plate for making off incoming cables.

39.8.14 Earthing

A copper earth bar of minimum size 25 x 6 mm shall be fitted at the bottom of the panel, preferably at the back. Where two or more panels are installed, the earth bars shall be connected together.

The earth bar shall be connected to the substation earth with a copper conductor of at least 95 mm^2.

All instruments, relays, switches, lamps and other Plant fitted to the circuit breaker panel, shall be connected to earth.

39.8.15 Internal Arc Classification (IAC)

The switchgear shall be designed and constructed to ensure that personnel are protected in case of the occurrence of an internal arc. In order to satisfy this requirement, the internal arcing type test must be done to IEC 62271-200 and satisfy all 5 criteria therein.

The gases generated, should explosions occur in any of the segregated compartments, shall be safely contained or vented such that operators or personnel on floor level at the front, back, or sides of the panel shall not be harmed.

Test certificates proving compliance shall be produced by switchgear suppliers to verify compliance with the above specification.

39.8.16 Protection and Instrumentation

39.8.16.1 Instruments and Meters

Each circuit breaker panel shall be equipped with meters and instruments as specified in Section 38 – Electrical General.

All meters and instruments shall be of the flush mounted type. They shall preferably be mounted on the hinged door of a separate instrument panel installed above the main housing, and mounted at a height of between 1,2 m and 2 m above the floor. The door shall be lockable with a single key.

39.8.16.2 Ammeters

Ammeters shall be 96 mm square with quadratic scale and shall be of the moving iron type, 1 Amp or 5 Amp as specified.

The ammeters shall be fitted with a slide-in scale. One scale shall be provided for each CT ratio. Full scale reading shall correspond to the rated primary current of the associated CT circuit, with an extended scale of 120%. Ammeters shall be able to take a 100% overload continuously and 40 x rated current for 1 second.

Ammeters shall be fitted with a zero adjustment screw.

Ammeters shall be colour-marked to indicate what phase they are connected to.

39.8.16.3 Voltmeters

Voltmeters shall be 96 mm square with quadrant scale and be of the moving iron type. Accuracy class 2.5.

The instrument voltage shall generally be 110V AC. Nominal system voltage shall be indicated by a red line on the scale. The scale shall extend to 115% of this voltage.

Where voltmeters are required on panels (normally on incomers), a single instrument shall be fitted together with a selector switch that can select any of three phase-to-phase voltages, and phase to neutral voltages on 4 wire systems.

Voltmeters shall be fitted with zero adjustment screws.

39.8.16.4 Energy, Power and Apparent Power Meters

kWh meters, kW meters and kVA meters shall be provided in accordance with Section 38 – Electrical General. Meters shall comply with BS 37 and be of accuracy class 2.

kWh meters shall have cyclometer dials and shall be direct reading, without the need for a multiplication factor. Combined kWh / kVA or kW maximum demand meters may have a

multiplication factor, but the same factor shall apply to both readings. The multiplication factor shall be clearly indicated as a single figure on a label next to the meter.

Maximum demand meters shall be reset from the front without removing the cover. The reset facility shall be able to be sealed. KWh meters shall also be fitted with seals.

The integrating period on Max demand meters shall be 30 minutes.

39.8.16.5 Multifunction Meters

Programmable electronic multifunction meters with data storage capability may be offered provided that full details are supplied. All software required for setting up and downloading the meters shall be provided at no additional cost. Programming shall be possible using a standard PC.

39.8.16.6 Protective Relays

Each circuit breaker shall be equipped with protection relays as specified for the particular function the breaker has to perform. The relays shall comply with the specifications as specified in Section 38 – Electrical General. The relays shall be from an approved supplier, and a type that is in general use in the RSA.

The relays shall be flush mounted and installed in the instrument panel above the main housing. All terminals shall be easily accessible.

All circuits that may be required for remote control, monitoring or indication shall be wired to terminals at the back of the circuit breaker panel.

The relays shall be withdrawable from their cases. CT circuits shall automatically be shorted out when a relay is withdrawn.

39.8.16.7 Live Line Indicators

For each cable connected to a switchgear panel, a set of three live line indicating lamps shall be fitted to the front of the panel.

These shall be Neon lamps powered by capacitive dividers in the bushings to indicate that the relevant cable is live.

39.8.17 Isolators

39.8.17.1 General Requirements

Isolators shall be suitable for fault-make and load-break. The fault level for the application shall be 18 kA unless otherwise stated in Section 38 – Electrical General.

Unless otherwise specified the full load rating shall not be less than 400 Amps continuous.

The operating mechanism shall be hand-operated, spring-assisted and the switch shall have “ON” “OFF” and “EARTH” positions. In the earth position the incoming cable shall be earthed.

Facilities shall be provided for locking the switch in all three positions. Interlocks shall prevent incorrect and unsafe operation.

39.8.17.2 Fuse Isolators

The three phases of a fused isolator shall trip simultaneously when any one of the fuses blows.

Interlocks shall be provided to ensure the following:

- To prevent closing of the fuse switch with a fuse holder not in position;
- To prevent access to fuses unless they are fully isolated; and
- To prevent switching to “earth” position unless fully isolated.

Test facilities shall be provided to connect test Plant to cable ends. Access to test facilities shall be fully interlocked to prevent inadvertent or dangerous access.

39.9 RING MAIN UNITS

The ring main units shall be housed in a single metal enclosure being a self-contained insulated unit. It shall be designed for use in MV ring networks and consist of two switch disconnectors for connecting into the ring, and a fuse switch combination that serves as a transformer tee-off unless otherwise specified.

The switchgear and busbar assembly shall be enclosed in a sealed housing that is filled with SF6 and this sealed system shall comply with the requirements of IEC 56.

The switches shall comply with the requirements of IEC 265 for “frequently operated switches”. The fuse switch combination for protecting the transformer shall have a breaking capacity as laid down in IEC 420 - unless otherwise specified the fuse rating shall be 63 amps, suitable for 630 kVA transformer rated voltage.

The fuses shall be enclosed in a separate compartment. The moving contact assembly of each switch shall be operated by a fast acting mechanism, independent of operator action. The operating mechanism shall provide for 3 positions namely; switch closed, switch open, earth switch closed. The design shall make simultaneous closing of the switch and the earthing switch impossible.

When the fuse-switch combination is closed, the opening mechanism shall be charged at the same time. Opening of the fuse-switch may be activated either by a push button, or by the striker pin of any one of the three fuses, if a fuse should blow. Position indicators shall be provided to clearly indicate the status of each switch and the fuse switch. The switch operating shafts and the push buttons shall be provided with pad locking facilities. When a switch is opened, under load any resulting arc shall be extinguished by the SF6 puffer technique.

Where specified, a fast acting circuit breaker shall be provided that complies with the following:

- Principle of operation : Vacuum or SF6
- Short circuit breaking capacity : 20 kA
- Making capacity : 40 kA
- Breaker operating mechanism : 3 position open, close, earthed
- Rated max load current : 200 A

The circuit breaker shall be provided with an integral inverse time overcurrent protection relay, operated off integral current transformers. Tripping shall not require any external power supply. The sensitivity of the relay shall be capable of being adjusted to suit the full load current of the transformer. The operating mechanism shall comply with the same requirements as the fuse switch stated elsewhere in this specification.

For each of the two ring circuits, 3 neon voltage indicator lamps shall be mounted on the ring main unit. The lamps shall be powered by capacitive dividers in the bushings and shall indicate that the relevant cable connected to the ring main unit is live.

Cable terminations for the transformer tee-off shall be made in a cable box that is suitable for the cable installation that is required to connect to the RMU.

The entire RMU shall be housed in a sheet steel enclosure that is mounted on a suitable skid base. The enclosure shall be painted and protected in accordance with Section 37– Painting and Corrosion Protection. Access to the RMU for operating and maintenance shall be facilitated by means of lockable wide-opening doors. Holes on the sides and back of the enclosure with a diameter of 150 mm shall allow for cable entries to the ring and transformer cables.

39.10 DISTRIBUTION TRANSFORMERS

39.10.1 Scope

This section deals with the design, manufacture, work testing, delivery to Site and off-loading (including the provision of cranes, labour etc., as necessary) of transformers, all in accordance with the details of the Specification. The transformer shall be either suitable for installation in a mini-sub or be free standing, as specified.

39.10.2 General

The transformer shall be in accordance with the requirements of the following Standards:

SANS 780: 2009	:	Distribution Transformers
SANS 1037: 2008	:	Standard Transformer Bushings
SANS 555: 2007	:	Mineral Insulating oil for Transformers
SANS 60076 part 1	:	Power Transformers

Each transformer shall be an oil immersed, three phase, sealed, low loss transformer meeting the requirements as specified.

Where dual ratio transformers are specified, the kVA rating required will be at the lowest HV voltage.

In addition to the standard fittings for minisub transformers as laid down in SANS 780 Table 1, each transformer shall be equipped with the following:

- An off-circuit, padlockable, snap-action tap switch, with positive indicating facilities;
- A second off-circuit, padlockable, snap action tap switch with positive indicating facilities in the case of dual ratio transformers;
- Drain valve with plug;

- Oil level gauge;
- Lifting lugs;
- Filling hole which will be properly sealed to ensure no ingress of dirt or moisture;
- Earthing terminal(s); and
- Skid underbase.

For minisub installations, the MV terminals shall be bushed and project into the MV compartment of the mini-sub where it shall be connected to the fused tee-off switch by way of the specified MV cables, or into a cable termination box.

The four LV terminals shall be of the bare stem porcelain bushing type of adequate rating.

The transformer is to be thoroughly dried out and tested at the manufacturer's works before delivery, the windings being submersed in oil, eliminating any need for further drying out and rendering the transformer ready for immediate service at full rated load.

The transformers shall carry the SANS mark and be tested in accordance with SANS 780. Certified copies of test certificates shall be forwarded to the Engineer as soon as possible after the tests have been carried out.

The transformer shall be protected against corrosion and have a final colour as specified in the Specification.

39.11 POWER TRANSFORMERS

39.11.1 Scope

This section covers the supply, delivery and complete installation of oil-filled power transformers as shown on the Drawings.

39.11.2 Interpretation

The transformer shall comply with the requirements of the latest revision of the following standards:

SANS 780	:	Distribution Transformers
SANS 1037	:	Standard Transformer Bushings
SANS 555	:	Mineral Insulating oil for Transformers
SANS 60076 1- 10	:	Power Transformers

39.11.3 Material

The transformer shall have copper windings.

All material surfaces of the transformers shall be treated to prevent corrosion and painted in accordance with Section 37 – Painting and Corrosion Protection.

All oil to air heat exchangers must be galvanized based on SANS 14713.

The transformer tank base must be of sufficient thickness to allow the transformer to be slid on the base. Four lifting lugs shall be provided for lifting the transformer. No tilting of the transformer is allowed during lifting of the transformer.

The transformer tank shall be designed to prevent the heating caused by stray flux from exceeding the allowed limits of temperature rise of the transformer.

Provision must be made for earthing the transformer tank on all four sides at a height of 500 mm above the base of the tank.

39.11.4 Transformer Construction

39.11.4.1 Oil Pressure Release Apparatus

Transformers shall be equipped with a spring loaded oil pressure release device which will release the internal oil pressure in the event of an internal fault. This device must be equipped with a normal open auxiliary contact that is able to give an electrical indication to the protection panel when in the open position. A status indicator must be present and must be clearly visible from ground level.

39.11.4.2 Buchholz Relay

The internal design of the transformer must allow free movement (ventilation) of gas to the Buchholz relay from anywhere inside the transformer. The Buchholz relay must be equipped with normal open contacts which will set off an alarm and trip switches on the control panel in the case of a gas build-up inside the transformer due to electrical faults. Gas generated in the tap changer must be able to activate a separate Buchholz relay should the gas not ventilate to the transformer Buchholz relay.

39.11.4.3 Oil and Winding Temperature

The position of the oil temperature thermometer in the transformer tank must be such that reading error due to heating by stray flux will be minimised. An oil temperature indicator as well as a winding temperature indicator shall be installed on the outside of the transformer tank. These indicators shall be easy to read and shall be equipped with two sets of normally open contacts. These contacts shall be able to activate alarm and trip switch signals respectively. The temperature values at which these alarm and trip switch signals should be activated shall be separately adjustable.

The winding temperature indicator shall indicate temperature rise caused by secondary current injected through a thermal device such that it shall accurately indicate actual winding temperature.

The transformer shall be equipped with a pocket to house a test thermometer.

39.11.4.4 Oil Valves

Lockable oil valves shall be fitted as specified. Isolating valves shall be installed between the transformer tank and all the external cooling apparatus. Tap changers as well as cable joints shall be installed to facilitate the removal of external Plant without drainage of the transformer.

Drainage and filter valves shall be installed as close as possible to the bottom of the tank. It shall also be adjacent to the reservoir. The diameter of the valves shall be at least 50 mm.

A valve with maximum diameter of 15 mm shall be installed close to the bottom of both the transformer and tap changer tanks. This valve will be used to take oil samples.

It shall be clearly indicated whether the above-mentioned valves are in the open or closed position.

39.11.4.5 Oil Conservator Tank

A single oil conservator tank shall be supplied. The conservator tank shall prevent the oil level from dropping below the top of the feeder pipe. It shall also prevent the overflow of oil with transformer temperatures that range between -10 °C and +115 °C.

This conservator tank shall have a sump where all deposits or impurities will remain. The tank shall have a lid that will allow for the cleaning of the inside of the tank. It shall be possible to refill the conservator tank by means of a 65 mm diameter airtight opening.

A lock valve shall be installed between the conservator and transformer tanks at the top side of the Buchholz relay. The conservator tank shall be equipped with a drainage valve.

Transformer oil may only come into contact with the atmosphere through the dehydrating breather. The oil level of all oils shall be indicated and shall be clearly visible from ground level.

All conservator tanks shall be fitted with oil level alarms.

39.11.4.6 Cooling

The type of cooling used shall be as specified in Section 38 – Electrical General.

All the necessary automatic control, motor contactors, motor protection and switches for forced cooling of the transformers shall be installed in a dust- and weatherproof kiosk. This kiosk shall be suitable for installation on ground close to the transformer. All the doors of the kiosk shall be lockable. The kiosk shall be equipped with a 240 V heater and lamp that switches on when the door of the kiosk is opened. All forced cooling apparatus shall be automatic or manual controllable.

Should the forced cooling fail, the master trip relay of the transformer shall trip. All motors shall be suitable for direct on-line starting.

39.11.4.7 Core

The electrical continuity of the core laminations shall not be interrupted. Where it is required by either insulation or cooling, tin-plated copper conductors shall be installed to give electrical continuity. The core shall be earthed via a removable link installed at an accessible position.
The core shall be mechanically strong enough to withstand all forces acting upon it during the transport of the transformer, electrical faults and when the core and windings are removed for maintenance.

The noise level shall not exceed the limits laid down by IEC 60076 part 10.

39.11.4.8 Windings

All windings shall comply with the relevant specifications listed above and the data given in the Technical Schedules at the time of tender. The rating and Vector group shall be as specified in Section 38 – Electrical General. Insulation levels for the windings and bushing shall comply with the values as specified in Section 38 – Electrical General.

39.11.4.9 Oil

All transformer oils shall comply with the requirements of SANS 555. If a transformer manufacturer finds it necessary to fill the transformer oil under vacuum it shall be clearly indicated on a plate fixed onto the transformer.

Breathing of the oil must only be possible through a dehydrating breather with an oil cup marked to indicate normal oil level. Direct contact between the desiccant in the breather and the outside air shall be prevented. The size of the breather shall be as specified in the relevant standards.

39.11.4.10 Terminations

The method of termination on both the high voltage and low voltage sides of the transformer shall comply with Section 38 – Electrical General.

Any current transformers, as specified in Section 38 – Electrical General shall be installed in the transformer bushings.

All clamps and terminations shall be designed to have low resistance and sufficient current carrying capacity. Bimetal clamps shall be used were copper and aluminium conductors are connected together.

Where applicable, bushings shall be suited for outdoor use with a minimum creepage distance of 23 mm per kV of the transformer voltage rating. Current carrying capacity of the bushings shall be at least 120% of rated current value.

39.11.4.11 Voltage Control

The transformers shall be equipped with manual no-load or automatic on-load tap changers with tap positions as described in Section 38 – Electrical General.

The electrical rating of the tap changers shall be at least equal to that of the transformer. The tap changers shall comply with the requirements of IEC 214.

Switches that interrupt the currents of the tap changers shall not be installed in the same insulating oil as the main transformer. These oils may at no time mix. No oil filter will be allowed between the transformer and the switch compartments. The circuit breaker that protects the transformer shall trip in case of a low oil level, or an increase in oil pressure or oil flow caused by a fault in the switch compartment.

All electrical control and actuating Plant shall be housed in a ventilated dust-, weather- and insect-proof kiosk with a 240 volt fused heater and switches that prevents condensation. It shall be possible to undertake tap changes with a handle for testing purposes and in case of an emergency.

An indicating light on the control panel shall indicate when the tap changing is in progress. It shall be possible to block tap changes when system faults occur.

Electrical control of the tap changer using a switch on both the control panel and tap changer respectively shall be possible. The position of the tap changer shall be indicated on the control panel.

A tap changer counter shall indicate the total number of tap changes performed. The tap changer and tap change control shall be suitable for operation in parallel to one or more other transformers with tap changers.

The OLTC control panel shall be suitable for indoor mounting and shall comply with the following:

a) The panel shall be a free-standing floor-mounted cabinet within which the required Plant shall be mounted.

b) The cabinet shall be 2 100 mm high and 600 mm wide.

c) The following Plant and instruments shall be mounted on the front of the control panel:

   i) Indicating lights : Supply off
   : Tap change in progress
   : Tap changer out of step

   ii) Tap position indication;

   iii) Voltage meter;

   iv) Over current tap changer blocking relay;

   v) Voltage regulator;

   vi) Control mechanism to tap up or down;

   vii) Automatic / manual selector switch;

   viii) Master / slave / individual selector switch;

   ix) Supply switch;

   x) Voltage regulator relay; and

   xi) Line drop compensator.

d) The voltage regulator relay shall be supplied from an 11 500 /115 V single phase voltage transformer. This relay shall have settings between 90% and 110% of the nominal voltage and shall have an adjustable time delay mechanism.

   The relay shall have a low voltage blocking mechanism preventing tap changes for voltages below 90% of the set minimum voltage.

e) The line drop compensator shall have independent settings for the X- and R-values, each with a reach of 0-20% of the nominal secondary voltage. Line drop compensation shall be added vectorially.

f) Overcurrent protection shall be included to prevent the tap changer from tapping when the current through any one phase of the transformer exceeds a pre-settable value which could vary between 100% and 200% of the rated capacity of the transformer.

g) The tap changer shall be equipped with a local manual tap change system with push button or crank handle operation.

Tap positions must also be indicated at the transformer.

39.11.4.12 Auxiliary Supply Wiring

All auxiliary supply wiring shall be 600 volt stranded conductor with PVC isolation properly numbered and neatly bundled together in an orderly fashion. Crimped lugs shall be used for the termination of such wiring.

Where separately mounted marshalling kiosks are supplied, all cables shall be installed and terminated between the transformer and marshalling kiosks. All cables shall be of the PVC SWA PVC type.

39.11.4.13 Name Plate

All transformers and tap changers shall be supplied with clearly visible name plates in accordance with IEC 76-1.

39.11.4.14 Terminal Strip

Transformers shall be equipped with a terminal strip in a marshalling kiosk positioned so that all protection and control cables from the different panels in the substation can be mounted there-on.

39.11.4.15 Taps

Drain and inlet filter taps for the transformer tank, positioned on opposite sides thereof, as well a main tank sample tap shall be provided.

39.11.4.16 Inspection Cover

An inspection opening with cover secured by bolts shall be provided to allow access to the bushing internal earth connections.

39.11.5 Installation

The transformers shall be placed on a concrete plinth as shown on the Drawings.

Within six (6) weeks after this Contract has been awarded, the appointed Contractor shall submit construction drawings to the Engineer consisting of:

a) Dimensions of all Plant;

b) Single line diagrams of tap changer control circuits; and

c) Complete operation manuals.

Refer to Section 48 – Tests on Completion.

39.11.6 Tolerances

Not applicable.

39.11.7 Tests

Before the transformer core is covered in the factory, the Engineer shall be notified to inspect it. The same ruling applies before the closing of the transformer tank.

The Engineer shall be notified before factory tests are conducted. All type tests and test certificates shall be submitted to the Engineer.

Tests conducted on Site include the following:

a) Winding ratio tests;

b) Impulse test;

c) Insulation tests;

d) Mechanical operation of tap changer;

e) Leakage current and tan delta tests;

f) Vector group tests;

g) Current transformer tests as specified;

h) Buchholz functional tests; and

i) Oil and winding temperature indication and functional tests.

Tests certificates of the above shall be submitted to the Engineer.

39.12 LOW VOLTAGE SWITCHBOARDS AND MOTOR CONTROL CENTRES (MCC)

This section covers the manufacturing and testing of flush mounted, surface mounted and floor standing switchboards and motor control centres for general installations in normal environmental conditions and for system voltages up to 1 kV.

MCC's and switchboards shall comply with the following standards:

SANS 10142 part 1	:	The Wiring code
SANS 1195	:	Busbars
IEC 60044	:	Current transformers
IEC 60439 part 1	:	Factory built assemblies for low voltages
IEC 60947 – 2	:	Low voltage switchgear and control gear – circuit breakers
IEC 60947 – 4-1	:	LV switchgear and control gear – contactors and motor starters
IEC 60947 – 5	:	Control circuit devices
SANS 1091	:	National colour standards for paint
SANS 1973 All Parts	:	Low-voltage switchgear and control gear

All switchboards and MCC's shall be manufactured and supplied from manufacturers who have Plant items that has been tested by a recognised testing institution to withstand the fault level stated in Section 38 – Electrical General. Relevant test certificates for Plant items of the same size and rating as that specified for this project shall be provided.

For low voltage switchboards and MCC's with a fault level higher than 10 kA, an approved and certified type tested manufacturer shall be used. Proof of this certification shall be supplied to the Engineer at the start of the Contract. These distribution boards shall be type tested in accordance with the latest revision of SANS 1973-1 and SANS 10142-1.

39.12.1 Switchboards

39.12.1.1 General

(a) Sizes

All switchboards shall be of sufficient size to accommodate all the specified switchgear as well as provide space for future switchgear. For every 6 (or part of 6) circuit breakers of a type and size on a switchboard, space for an additional circuit breaker of similar size shall be allowed unless future space requirements are clearly specified. A minimum of thirty percent (30%) additional space for future extensions must be allowed for in the switchboards and MCC's as specified.

(b) External Dimensions

Prior to manufacture, the dimensions of the switchboards and MCC's must be checked for adequate space for installation, and compliance with the regulations, with respect to the control room drawings depicting the locations where the switchboards and MCC's are to be installed. This also applies to access doors and openings for the control rooms.

(c) Positions

The Contractor shall ascertain the exact position of switchboards and shall arrange timeously for the installation of cable sleeves, opening in the structure, flush draw trays behind switchboards and supports over cable trenches.

(d) Mounting Heights

In general, flush and surface wall mounted switchboards shall be mounted 1.4 m above finished floor level - measured to the centre of the switchboard. The upper ends of switchboards may not be higher than 2.3 m above finished floor level.

39.12.1.2 Construction of Flush Wall Mounted Switchboards

(a) Bonding tray

Bonding trays for flush mounted switchboards shall be rigidly constructed using 1.6 mm thick galvanized steel, braced and reinforced. Formed gussets shall be provided at the corners. All the tray joints shall be properly welded. A brass or cadmium plated steel earth connecting stud and nut shall be provided.

(b) Expanded Metal

Where switchboards are to be built into 114 mm thick walls expanded metal shall be spot welded to the rear of the bonding trays. The expanded metal shall protrude at least 75 mm on each tray side to prevent the plaster from cracking.

(c) Knock-outs

Ample knock-outs shall be provided in the top and bottom ends of each switchboard tray to allow for the installation of conduits for the specified and future circuits. Knock-outs shall be allowed for any size of specified conduit. Provision shall however, be made for termination of at least 2 x 25 mm dia. conduits at the top and 2 x 25 mm dia. conduits at the bottom of each tray.

(d) Architrave Frame

The architrave frame shall be of 1.6 mm thick sheet steel with bevelled edges. The architrave frame shall accommodate the chassis, panels and doors. The architrave shall overlap the bonding tray by at least 25 mm on each side. The architrave frame shall be fixed to the tray in such a manner to allow for depth adjustment and irregularities in the wall.

(e) Extension Frames

Semi-flush mounted switchboards shall be equipped with extension frames. Generally, the frame depths shall be 40 mm but may be altered to suit each application.

(f) Chassis

The chassis for mounting of switchgear and Plant shall be of rigid construction and shall be fixed securely to the architrave frame or bonding tray by means of bolts screwed into tapped holes or bolts and nuts. Self-tapping screws are not acceptable. The chassis position shall be adjustable in the horizontal plane.

(g) Panel (Faceplate)

A suitably stiffened faceplate manufactured of 2.0 mm thick sheet steel shall be installed in the architrave frame for flush mounting of switchgear. The panel shall have machine punched slots for housing the specified and future switchgear, instruments, fuse holders, isolating switches, indicator lamps, etc. In exceptional cases contactors will be allowed to protrude through the panel. Blanking plates shall be provided in positions where future switchgear will be installed.

The distance between the inside of the closed doors and the panel shall not be less than 40 mm.

No Plant may be mounted on the panel (faceplate) unless it is permanently hinged to the switchboard frame.

(h) Fixing of Panels

The panel for each switchboard shall be secured to the architrave frame by means of 6 mm studs and chromium plated hexagonal domed nuts. Alternatively, the panel may be secured to the

architrave frame by means of two pins at the bottom and a latch or lock at the top of the panels. Self-tapping screws will not be allowed. Where it is required that Plant be mounted on the panel, the panel shall be securely hinged to the switchboard frame.

(i) Hinged Panels

Two chromium plated handles shall be provided on each front cover. The handles shall be mounted at the top and bottom of each panel.

(j) Doors

All switchboards shall be equipped with doors unless otherwise specified. The doors shall be of a smooth flat finish suitably braced to ensure stiffness and when in the closed position shall be flush with the architrave frame. The doors shall be of 1.6 mm sheet steel. The door width shall not exceed 600 mm. The corners shall be welded and smoothed.

(k) Door Handles and Catches

All switchboard doors shall be equipped with handles and catches. Locks shall only be provided when specified. In all cases where lockable doors are required, the switchboard doors are higher or wider than 450 mm, handles consisting of a push-button-and-handle combination with spring loaded latch or rotary handle-and-catch combination shall be installed. Switchboard doors smaller than 450 mm in height and width may be equipped with spring loaded flush mounted ring type latches. Square key operated catches are not acceptable unless specified in Section 38 – Electrical General.

39.12.1.3 Construction of Surface Mounted Switchboards

This Section refers to surface mounted sub-switchboards and not to floor standing main switchboards in substations or sub-main switchboards.

(a) Switchboard Tray

Surface mounted switchboards shall be equipped with a 1.6 mm sheet steel reinforced tray. Securing lugs shall be provided to fix the tray to walls or any other structure. A solid brass or cadmium plated steel earth connection stud and nut shall be provided.

(b) Construction

All joints shall be securely welded. The tray shall be square and neatly finished without protrusions. The front tray sides shall be rounded with an edge of at least 20 mm to accommodate flush doors.

The requirements of chassis, panels and doors shall be as specified for flush mounted switchboards. The doors shall be hinged and shall fit flush in the frame in the closed position. Knock-outs shall not be provided unless specifically called for.

39.12.1.4 Construction of Floor Standing Switchboards

(a) Frame

Free standing switchboards shall be manufactured from a solid angle iron, channel iron or 2 mm minimum folded metal framework and a solid U-channel base frame, sufficiently braced to support all Plant and span floor trenches and access holes. Care shall be taken to prevent distortion due to localised heating during welding. All welds shall be ground smooth and the joint wiped with plumber's metal in order to provide a smooth finish. The design of the frame shall provide for the mounting of main circuit breakers, busbars and other Plant.

(b) Side Panels

The side, top and rear panels shall be removable and shall be manufactured from 2 mm minimum sheet steel. The panels shall have upturned edges which fit over lips on the switchboard frame. The panels shall be fixed to the frame by means of studs and chrome plated hexagonal domed brass nuts. Where switchboards are installed in vertical building ducts or against walls, the rear and side panels may consist of a single folded sheet which is either bolted or welded to the frame or which forms part of the folded metal frame.

(c) Front Panels

The front panels of floor standing switchboards shall be hinged. The panels shall be arranged in multi-tiered fashion to allow for the logical grouping of Plant. The hinged front panels shall have a dished appearance with 20 mm upturns which fit over a lip on the switchboard frame. Alternatively, the hinged panels shall be folded edges and shall be fitted flush or slightly recessed in the switchboard frame. The latter method shall be used where doors are required. Corners shall be welded and smoothed.

The panels shall be of 2 mm minimum sheet steel with machine punched slots to allow for the flush mounting of all instrumentation, switchgear toggles and operating handles. A minimum clearance of 50 mm shall be maintained between the rear (taking into account terminals and other projections) of Plant mounted on the panels and the frame chassis of the switchboard.

Separate panels shall preferably be provided for the mounting of instrumentation and for covering flush mounted switchgear.

Hinged panels shall be suitably braced and stiffened to carry the weight of flush mounted Plant and to prevent warping.

Long pedestal type hinges with two fixing bolts per hinge shall be used to support hinged panels with flush mounted protection relays and similar Plant and panels higher than 600 mm. 16 mm Pedestal hinges or similar hinges with single fixing bolts may be used on small panels.

Pedestal hinges shall be arranged in opposed fashion so that panels cannot be lifted off.

A tubular chromium plated handle shall be fitted on each panel.

Blanking plates shall be fitted over slots intended for future Plant. These plates shall be fixed in such a fashion that fixing holes do not need to be drilled through the front panel.

Panels shall be fitted with rubber or neoprene seals.

(d) Securing of Front Panels

Hinged panels shall be secured in position by means of square key operated non-ferrous fasteners designed to draw the panels closed. Self-tapping or captive screws are not acceptable. When non-hinged removable panels are specified, they shall be secured in position by means of 6 mm studs and hexagonal chromed brass domed nuts and washers. Non-hinged removable panels may alternatively be secured in position by means of two pins at the bottom and a latch or lock at the top. The handles of these panels shall be at the top and bottom.

(e) Chassis

A suitably braced chassis for the mounting of switchgear and Plant shall be firmly secured to the frame of the switchboard. Circuit breakers and isolating switches which are not of the moulded case air break type and the insulators of busbars for ratings of 200 A and above may be secured directly to the framework.

(f) Sections

The Contractor shall verify the position of all switchboards on Site. For ease of transportation and to facilitate access to the allocated accommodation, the switchboards may be manufactured in sections. The section of the boards shall be of suitable size to pass through doorways, passages, etc. Each section shall be rigidly manufactured to ensure that damage to the switchgear will not occur during transportation and handling. When positioned, the sections shall be bolted together.

(g) Grouping of Switchgear

The switchgear shall be logically arranged and grouped. Depending upon the number and size of components a common front panel may be installed over one or more groups of Plant.

(h) Busbars

Solid copper busbars, with suitable current ratings, shall be provided in the switchboard.

(i) Earth Busbars

An earth busbar shall be provided in a suitable position in the switchboard.

(j) Cable Gland Plate

A cable gland plate shall be installed 300 mm above the bottom of the switchboard to house the cable glands. The gland plate shall be suitable for the type of gland or end boxes to be used. Cable glands for top exit cables shall be secured to the top non-removable panel of the switchboard. A P4000 channel or other approved support shall be provided to carry the weight of the cable and remove mechanical stress from the cable glands.

(k) Termination of Conduits

Conduits shall be terminated on the gland plate or top non-removable panel. If the panel is removable it shall be welded to the switchboard frame before conduit or cable terminations are made.

(l) Securing

Switchboards shall be firmly secured to the floor and/or wall and shall be equipped with the necessary securing lugs.

(m) Ventilation

Switchboards shall be properly ventilated, especially cubicles containing contactors, transformers, motor starters and other heat producing components.

(n) Storage

Switchboards which cannot be installed and put into service immediately shall be stored to maintain the Plant in a clean and dry condition and shall be placed on a level surface.

39.12.2 Motor Control Centres (MCC)

39.12.2.1 Design

Motor Control Centres (MCCs) shall be designed to suit the system fault level as specified or shown on the Drawings and which shall be deemed to be the maximum currents occurring at the motor control centres under symmetrical short circuit conditions on the line side of any limiting device.

The duration of the maximum short circuit currents shall be deemed to be 3 seconds.

Evidence, in the form of certificates by a recognised testing authority, of the ability of the motor control centres offered to withstand satisfactorily the prospective fault conditions shall be available and submitted if requested to the Engineer.

39.12.2.2 Construction

Motor Control Centres shall be of the floor-standing, indoor dust-protected and vermin-proof type, manufactured from sheet steel having a minimum thickness of 2.0 mm.

Motor Control Centres shall be made up of one or more, modular, bolted construction, free-standing vertical panel assemblies, hereinafter referred to simply as “panels”, bolted together to form an extensible composite MCC of uniform appearance, and mounted on a steel plinth of minimum height 75 mm.

Each panel shall consist of a metal-enclosed, dead front, extendible, vertical steel structure capable of housing power buses, an earthing bus, motor starters, fused switches, metering and control Plant, etc. Each panel shall be capable of being divided into segregated compartments, each with a separate door, for the housing of motor starters or other Plant.

Unless otherwise specified, each panel shall be 610 mm wide and 600 mm deep, and the height above finished floor level shall not be more than 2.3 m.

Three basic types of Motor Control Centre construction will be required and will be detailed in Section 38 – Electrical General. The types of construction are as follows:

- Standard construction - having front access to control gear and other electrical Plant, and rear access for the termination and connections of cables;
- Front access only construction; and
- Back-to-back construction - where access to control gear and cable zone are on the same face.

A cabling zone cubicle shall be provided for each panel. The cabling zone cubicle shall be provided with the necessary cable gland plate and hinged doors and shall have a minimum width of 300 mm.

Segregated or non-segregated compartments may be specified for any of the above types of construction.

Motor Control Centres shall have front-mounted Plant, except in the case of back-to-back construction.

Panels shall be constructed so that the different zones for control gear and/or horizontal and vertical busbars, incoming feeders, bus-wires and cable terminations, are completely isolated and segregated from each other by means of steel barriers and in such a manner that prospective damage resulting from faults will be minimised and confined to the zone in which the fault occurs.

Where starters or feeders are each required to be housed in a separate compartment, each panel shall be constructed so that dividing plates will ensure a totally enclosed and separate compartment ensuring that access from one compartment to its adjacent compartment is totally prohibited, other than through specified orifices intended for inter connecting control wiring where necessary.

Each separate compartment shall be provided with a hinged door which shall be arranged so that it cannot be opened while the apparatus contained therein is alive, unless this apparatus is fully shrouded or screened to prevent inadvertent contact.

Where the apparatus contained in the compartment is provided with an isolating switch or MCB, the door shall be mechanically interlocked so that it cannot be opened unless the switch is in the “OFF” position.

Withdrawable functional units shall have a plug-in connection on the line supply, load and control circuits.

A mechanical interlock shall be provided to ensure that the functional unit cannot be engaged or disengaged unless the main contacts of the switch-disconnection device are fully open.

These facilities shall also be provided to padlock withdrawable functional units in all the following positions:

- The test position with mechanical movement of withdrawable part;
- Test position without mechanical movement of the withdrawable part;
- Isolated position with mechanical movement of the withdrawable part;
- Isolated position without mechanical movement of the withdrawable part; and
- Removed position.

Empty panels and compartments shall be equipped with fundamental horizontal and vertical busbars to enable easy additions to be made to the motor control centre once it has been installed.

Each completed Motor Control Centre shall be divided into transportable sections, each section provided with removable lifting lugs which shall be bolted to the main framework of the transportable section. The framework shall be designed so that no distortion of the board will take place when hoisted and handled.

All screws, bolts and nuts shall be hexagonal cadmium plated and in accordance with Metric Commercial Standards and shall be rust-proof. Nuts protruding beyond exterior surfaces shall be domed.

Self-tapping screws shall not be used under any circumstances, unless approval to do so has been given by the Engineer in writing before manufacture has commenced.

Panels shall be provided with hinged doors for access to cable termination zones. Bolted on covers will not be acceptable. Hinged doors shall be provided with “Perano” or “Barker-Nelson” 6 mm catches and “Barker-Nelson” pedestal hinges.

Each Motor Control Centre shall be provided with a suitable enclosure or pocket on the inside for housing one full set of Drawings and a maintenance and instruction manual for that MCC.

39.12.2.3 Busbars

Horizontal power busbars and vertical busbar droppers shall be copper, of constant cross-sectional area throughout their length, and shall be mechanically braced for the short circuit current value as specified. All busbars shall be of suitable rating and not more than 1.8 ampere per mm^2.

Contact surfaces of busbars at splices and bolted joints shall be silver plated or chemically cleaned by a process approved by the Engineer.

Busbars shall be colour coded.

Holes in busbars shall be jig-drilled or punched so that they are perfectly round and only with sufficient clearance to suit the correct size of bolt. All busbar ends behind the blanking off covers shall be pre-drilled for fishplates.

The main horizontal busbars shall be completely isolated from the other zones. The vertical power busbar droppers on each panel shall be insulated or isolated so that with the compartment door open or the main cableway door open, access cannot be gained to live busbars.

Main horizontal and vertical power busbars shall have continuous ampere ratings as specified. However minimum ratings for MCCs shall be applicable as follows:

- Main horizontal busbars - 600 Amps; and
- Vertical busbar droppers - 300 Amps.

Horizontal and vertical busbars are to be fixed on non-tracking hazite insulators or equal approved, at suitable intervals to withstand the dynamic forces under the full short circuit conditions. Bolted joints in busbars are to be joined using copper fishplates of equal section to the busbars and using high tensile bolts and lock-washers.

39.12.2.4 Wiring

(a) Cabling

Cables connected to incoming or outgoing circuits shall terminate on the gland plate supplied for this purpose. The cable conductors shall be connected directly to the appropriate switchgear or to busbars.

(b) Terminal Strips

External wiring for low voltage, control interlocking alarm, measuring and D.C. circuits shall terminate on numbered terminal strips. The correct terminal size as recommended by the manufacturer for each conductor to be connected shall be used throughout. The terminal numbers shall appear on the wiring diagrams of the MCC. Terminals for power wiring shall be separated from other terminals. Terminals for internal wiring shall not be interposed with terminals for external circuits.

(c) Current Ratings

The current rating of conductors for the internal wiring shall be sufficient to carry the maximum continuous current that can occur in the circuit.

Conductor ratings for PVC insulated, single core conductors are specified in Table 39/1 for maximum internal switchboard ambient temperatures of 30°C. These values shall be derated for ambient temperatures that are likely to exceed 30°C. Where currents exceed the rating of 70 mm² conductors, busbars shall be used.

TABLE 39/1
PVC INSULATED CONDUCTOR RATINGS

NOMINAL CROSS SECTION (mm^2)	CONDUCTOR RATING (A)				
	NUMBER OF CONDUCTORS BUNCHED TOGETHER				
	1	2 - 3	4 - 5	6 - 9	10 or more
1.5	13	12	10	9	8
2.5	17	16	14	12	10
4	22	20	18	16	13
6	29	26	23	20	17
10	40	36	32	28	24
16	55	49	44	38	33
25	74	67	59	52	44
35	93	74	74	65	56
50	119	107	95	83	71
70	148	133	119	104	89

(d) Internal Wiring

Standard 600 V grade PVC insulated stranded annealed copper conductors to SANS 1507 shall be employed for the internal wiring of MCCs. Current ratings are specified in (c) above. If the internal ambient temperature of the MCC is likely to exceed 60°C, stranded 600 V grade copper wiring shall be insulated with heat resistant insulation.

(e) Load end Connections

The supply end connections to Plant shall as a rule be at the top and the load end connections at the bottom. Where the load and supply ends of the mains circuit breaker of a MCC is not indicated, the load may be connected to the top end only if the wording “TOEVOER/LINE” and “LAS/LOAD” is correctly indicated on the circuit on the circuit breaker.

(f) Wiring to Circuit Breakers

Plant with a rating exceeding 200 A shall be connected by means of busbars to main busbars.

(g) Identification

The colour of the conductors for all 220 V circuits shall correspond to the colour of the supply phase for that circuit. Neutral conductors shall be black. All other conductors in the supplying control circuits, etc., shall be coded in colours other than those specified above. A colour code shall be devised for each and the colour code shall be shown on the wiring diagrams. All conductors that terminate at terminal strips and all conductors used for the internal wiring shall further be identified at both ends by means of double cable marking ferrules. PVC or other tape is not acceptable. The numbers on the markers shall also be shown on the wiring diagrams.

(h) Control and Instrumentation Wiring

All internal wiring shall be carried out in PVC insulated wire with a minimum size of 1.5 mm^2 flexible conductors. Each end of every wire shall be marked with the wire number by means of plastic cable markers of the “Partex-Haley” or “Klippon” type. All wiring shall be neatly grouped and run in plastic wiring channels of adequate size with covers and additional spare capacity of at least 25% shall be allowed for in the wiring channels. All wiring shall be brought out to terminal blocks for connections to external wiring and shall enter or exit from the slots which are provided in the wiring channel.

All panel wiring shall be terminated by means of correctly sized compression lugs.

The wire used shall comply with the following colour coding:

Red	:	24 V DC (+ 24 V line)
Black	:	24 V DC (0 V Line)
Brown	:	220 V Line
Blue	:	220 V Neutral
White	:	Current Transformers
Green or Green/Yellow	:	Earth

The minimum voltage rating of control wiring shall be 300 V AC.

Split or clip-on wiring markers shall not be used under any circumstances.

39.12.2.5 Circuit Breakers

Circuit breakers shall comply with the requirements laid down in SANS 156.

The incoming terminals of single pole miniature circuit breakers shall be suitable for connection to a common busbar.

Circuit breakers used on any one particular service shall be supplied by a single manufacturer.

The continuous current rating, trip rating and rupturing capacity of the circuit breaker shall be as required by Plant.

All Miniature Circuit Breakers (MCB's) shall be of minimum kA rating as per the Drawings and shall be of the thermal magnetic trip free type.

Moulded Case Circuit Breakers (MCCBs) shall have a fault rating as specified. MCCBs shall be of the manually operated and trip free type with thermal as well as instantaneous magnetic trips on each pole.

Where MCCBs are used as back-up in motor starters, these shall be mechanically interlocked with vari-depth handles on the compartment door to prevent the door being opened while the apparatus inside the compartment is alive.

39.12.2.6 Earth Leakage Relays

Single phase or three phase earth leakage relays with associated double, triple pole or 4 pole circuit breakers shall be supplied and installed in all circuits feeding socket outlets and other general power circuits in compliance with SANS 10142.

The relays shall operate on the core balance (current balance) principle. The operation shall be independent of mains voltage and shall function with any of the supply conductors (and neutral) disconnected or broken.

The sensitivity and operating response of the relay shall be such that instantaneous tripping will occur at a total earth leakage current as per the Drawings. The unit shall have compensation for ambient temperature variations, and the sensitivity and operating response time shall be maintained over the range of normal frequency variations. Stability of operation, long life and retention of characteristics are essential.

The unit shall be provided with integral test facilities by means of which the correct functioning of the unit may be tested.

The circuit breaker and earth leakage relay shall be suitable for operation on a 220 - 250 volt, 50 Hz supply on single circuits and 380 - 440 volt, 50 Hz supply on three phase circuits.

Internal earth leakage units may be used as an alternative.

For motor starter circuits, Earth leakage relays are to be as follows:

- 0 to 75 kW - 250mA instantaneous EPC type E1-Sec-X and Transcore X; and
- 90 kW up - 375mA EPC AEL-Sec-T Curve 1 and Transcore T.

39.12.2.7 On-load, Fault-making Switches

On-load, fault-making switches shall be of the triple pole, hand operated, panel mounting, air-break type suitable for operation on 380 - 440 volt, 50 Hz AC systems.

The contacts shall be of silver alloy and the switch mechanism shall be of the quick-make, quick-break type.

The switches shall be capable of opening and closing the full current rating of the switch. The current rating of the switch shall be in excess of the full load current of the circuit which the switch will be required to open. In the case of motor circuits, the switch shall be capable of breaking the “stalled rotor current” of the motor.

The switches shall further be capable of being closed onto a fault. The switches shall be adequately rated to withstand the maximum fault current that can occur at the point in the circuit for a sufficient time to allow the back-up protection (circuit breakers or fuses) to open the circuits. The switches shall be suitable for mounting behind MCC panels.

To distinguish the switches from circuit breakers, the operating handle shall have a distinctive colour, preferably green, or other clear indelible indication.

39.12.2.8 Rotary Switches

Rotary switches shall be of the cam actuated or wiping air-break type with two breaks per pole. The required number of poles and number of functions shall be provided by the assembly of switch units on a common spindle. Unless specified to the contrary the switches shall be constructed for mounting behind a flush panel and shall be provided with a suitable faceplate and operating handle.

The contacts shall be of silver alloy and the latching mechanism shall ensure positive accurate positioning of the handle in relation to faceplate markings. The voltage and current ratings shall be as required by the circuit and control function and the making capacity shall be at least three times the normal current rating.

39.12.2.9 Combination Fuse Switch Unit

The fuse switch shall be of the triple pole type.

The fuse type cartridges shall comply with BS 88, Category of Duty AC 16, 33, 46 or 80 suitable for a 415 V 50 Hz system. Category of duty shall be matched to the fault level at the point where the fuses are installed.

The fuse switch shall have a hand operated lever and the “ON” and “OFF” positions shall be clearly marked.

Fuse switch units shall be of the double air-break, quick-make, quick-break type and shall have a spring mechanism smoothly driven by springs on both sides of the mechanism.

The fuse links shall be fully isolated when the switch is in the “OFF” position, and interlocks shall be provided to prevent the cover being opened when the switch is closed and to prevent the switch being operated with the cover open.

39.12.2.10 Fuses and Fuse Holders

High rupturing capacity fuses (HRC fuses) shall comply with the requirements of SANS 60269 with a fusing factor of 1.5.

Fuses which are not mounted integrally with switches shall be mounted on insulated draw-out carriers (holders) which hold the fuses positively after withdrawal.

Each fuse link and holder shall incorporate a visual inspection eye for fault location.

Should live terminals become exposed after the withdrawal of fuses, rigid barriers shall be provided between adjacent sets of terminals to prevent accidental contact during withdrawal or insertion of the fuses.
Control circuits shall be protected by suitably rated fuses. Instrument fuses shall be mounted in close proximity to the relevant instrument. These fuses shall be clearly labelled with engraved “TRAFOLYTE” or similar strips indicating use, rating and duty (where applicable).

39.12.2.11 Contactors

Contactors shall be of the open or totally enclosed, triple or double pole, electromechanically operated air-break type suitable for 380 – 440 V or 220 – 250 V.

Contactors shall be of modern design with the following characteristics:

a) Enclosed coil;

b) A permanent air gap in the magnetic circuit to prevent sticky operation;

c) Provision for quick and simple inspection of contacts; and

d) Clearly marked main and auxiliary terminals.

Contactors which are not located in switchboards shall be housed in enclosures which comply with IP 54 of SANS 60529.

The current rating of the contactors shall be as specified for the circuit with a switching duty in accordance with the IEC Publication 158 - 1, utilisation category AC1 for lighting and power circuits and utilisation category AC3 for motor starting.

The magnetic system of the contactor shall be carefully designed and all laminations tightly clamped to ensure that when the armature is closed and full voltage at normal frequency is applied to the coil, the contactor will not emit more noise than the hum associated with any properly constructed laminated core with tightly clamped laminations. Noisy contactors will not be accepted.

Non-current carrying metallic parts shall be solidly interconnected and a common screwed earth terminal shall be provided. The contactor shall be earthed to the switchboard earth bar.

Latched contactors shall be provided with a trip coil and a closing coil. The Contactor shall remain closed after de-energising the trip coil.

Contactor operating coils shall have a voltage rating as required by the control circuitry and shall have the limits of operation and temperature rise as specified in Table IV of the IEC Publication 158-1. Latched contactors shall be capable of being tripped at 50% of the rated coil voltage.

Contactors for normal / standby change-over circuits shall be electrically and mechanically interlocked.

Contactors with provision to add auxiliary contacts on Site are preferred. Contactors with permanently fixed auxiliary contacts shall have at least 1 x N/O and 1 x N/C spare auxiliary contacts. Where the number of auxiliary contacts required is greater than the contacts that can be accommodated on the contactor, an auxiliary relay or additional contactor shall be provided to supply the additional contacts.

Auxiliary contacts shall be capable of making, carrying continuously and breaking 6 A at 220 V AC, unity power factor.

Spare auxiliary contacts shall be wired to numbered terminal strips in the MCC and shall appear on the MCC Drawings.

39.12.2.12 Indoor Surge Arrestors

Surge arrestors shall be of the single pole indoor type suitable for mounting on a rail and suitable for the protection of electrical appliances.

In the event of damage caused by very severe overloads, the arrestor shall be automatically disconnected from the mains and a visual indication given to show that the arrestor has been disconnected.

The arrestors shall be suitable for systems with an earthed neutral and voltages up to 250 volts to earth.

39.12.2.13 Voltmeter Selector Switches

Voltmeter selector switches shall be suitable for a three phase 50 Hz system and rated for the system voltage.

Voltmeter selector switches shall be arranged to provide one “off” position and six metering positions in order that the phase-to-phase voltage and phase-to-neutral voltages can be read on the voltmeter. The switches shall be break-before-make type.

The operating knob and indicator plate shall be manufactured of a suitable insulation material. The switch positions shall be clearly and indelibly marked thereon.

Switches shall be suitable for panel mounting with the operating knob and indicator plate on the front of the panel and the switch and contacts behind the panel.

The selector switch shall be situated immediately below or adjacent to the voltmeter.

An engraved label shall be fixed below the selector switch indicating its function.

39.12.2.14 Ammeter Selector Switches

A single ammeter with selector switch shall only be allowed in exceptional circumstances. As a rule, 3 ammeters shall always be provided unless specified to the contrary.

Where ammeter selector switches are specified, they shall be make-before-break types. The wiring shall be arranged so that the current transformer terminals are short circuited when the ammeter is not connected across them.

39.12.2.15 Pushbuttons

Push buttons shall be of robust construction and shall be suitably rated for the switching duty with provision for the control functions specified.

Push buttons shall be suitable for flush mounting on MCCs.

Red push buttons shall generally be used for tripping, stopping or switching off functions and green push buttons for starting or switching on functions.

Push buttons installed in walls or on other non-metallic surfaces, shall be mounted in purpose-made flush or surface mounted boxes equipped with a mounting plate with slotted holes and suitable cover plate.

Illuminated push buttons, key-operated push buttons, button plates, legend plates etc., shall be supplied as specified.

Push buttons shall comply with the requirements of the relevant clauses of BS EN 60730 or VDE 0660.

39.12.2.16 Relays

The coil, contacts and operating mechanism of all relays shall be contained in a transparent, dust proof enclosure of plastic or other suitable synthetic material.

Relays shall be supplied with plug-in bases.
Relay bases shall be fitted with wire-spring type retaining clips to ensure positive relay contact even when the switchboard is subjected to severe vibrations.

Relay contact ratings shall be adequately rated for the intended duty.

Relays shall provide the type of switching function specified. Late-make or late-break functions, etc., shall be inherent in the design.

39.12.2.17 Time Switches

Time switches shall be suitable for use at the system voltage.

Time switches shall be fitted with a manual over-ride switch. An external by-pass switch shall be provided in all time switch circuits.

39.12.2.18 Voltmeters

Voltmeters shall be 400 volt moving iron, suppressed zero type, scaled from 0 - 500 volts. The 400 volt mark shall be clearly indicated with a red line on the scale.

Voltmeters shall be suitable for flush mounting on vertical panels and shall be provided with studs for rear connection. The terminals of voltmeters mounted on hinged front panels shall be shrouded or covered to prevent accidental contact when the panels are open.

Voltmeters shall be suitable for operation on a 50 Hz system and shall be manufactured in accordance with the requirements of BS 89 (current) for industrial grade accuracy. The voltmeters shall withstand a test voltage of 2 kV.

Voltmeters shall be fitted with zero adjustment screws.

Voltmeters shall be screened to prevent magnetic interference and shall be fitted with anti-static glass.

Each voltmeter shall be marked to indicate the appropriate phase to which it is connected. Where 3 voltmeters are provided, they shall be installed in a horizontal line. The voltage which is being measured shall be clearly marked on each.

Where voltmeters are connected to potential transformers, the ratio of the potential transformers shall be marked on the voltmeter faceplate.

39.12.2.19 Ammeters

Ammeters shall be of the moving iron type suitable for flush mounting on vertical panels and shall be provided with studs for rear connection. The terminals of ammeters mounted on hinged front panels shall be shrouded or covered to prevent accidental contact when the panels are open.

Voltmeters, ammeters, frequency meters, etc., shall have the same dimensions for a particular application.

Ammeters shall be manufactured to the requirements of BS 89 (current) for instrumentation of industrial grade accuracy. Where the calibration and current transformers are to be specified, ammeters shall have a full-scale deflection of 125% of the rated current of the circuit. Full load ratings shall be indicated with a red line. Ammeters shall withstand a test voltage of 2 kV.

Ammeters used in motor circuits shall cater for motor starting currents by condensed over scales up to 100% overload scaling.

Ammeters shall be fitted with zero adjustment screws.

Ammeters shall be screened to prevent magnetic interference and shall be fitted with anti-static glass.

Each ammeter shall be marked to indicate the appropriate phase to which it is connected. Where 3 ammeters are provided, they shall be installed in a horizontal line. The current being measured shall be clearly marked.

The ratio of current transformers shall be marked on the ammeter faceplate.

Ammeters shall be suitable for the environment in which they are installed.

39.12.2.20 Maximum Demand Ammeters

Maximum demand ammeters shall comply with the requirements of ammeters except that in addition to the moving iron ammeter indicating instantaneous current, a maximum demand ammeter employing a bi-metallic spiral device which indicates mean current value integrated over a 15 minute period and a residual pointer to indicate the maximum mean current reached during any period between manual re-settings, shall be combined in the same housing.

All three indications shall be given on concentric scales. Instruments having small moving iron ammeters with window cut-out scales are not acceptable.

The bi-metallic system shall incorporate ambient temperature compensation.

The residual pointer shall be resettable from the front glass panel.

39.12.2.21 Kilowatt Hour Meters

The kilowatt hour meter shall be manufactured in accordance with the requirements of BS 5685. The meter shall be suitable for operation on a 50 Hz AC system with commercial grade accuracy.

The meter shall provide a direct reading in kWh without the use of multiplication factors.

All meters driven by current transformers shall have a 5 A nominal current input.

39.12.2.22 Current Transformers

Current transformers shall comply with the requirements of the latest edition of IEC 60044. Where the current value of the primary side is more than 50 A (irrespective of ratio), the current transformer shall be of the ring type with an opening to suit the dimensions of the conductor or busbars.

Current transformer ratios shall match the rating of the circuit and the scaling factor and saturation points required on instruments or by circuit protection Plant.

Unless specified to the contrary, current transformers shall have a class 1 accuracy, a capacity of 5 VA and be suitable for operation on 50 Hz AC systems up to 660 V.

Each current transformer shall be provided with a robust mounting bracket and proper terminal studs on the circumference of the coil for connections.

A nameplate shall be fixed to the coil circumference in such a position that it can easily be read from outside the switchboard after removal of the access panels. The nameplate shall clearly indicate class, rating, ratio and function.

Current transformers shall be mounted on rigid supports in such a fashion that the connections to the switchgear and connections to the coil terminals can be installed without difficulty.

Current transformers shall be capable of withstanding the maximum fault current that can occur at the point in the system for the time taken by the circuit protection devices to clear the fault.

39.12.2.23 Hour Meters

Electrically operated cyclometer type hour meters suitable for flush mounting on vertical panels shall be provided where specified. The meters shall be provided with studs for rear connection. The terminals of meters mounted on hinged front panels shall be shrouded or covered to prevent accidental contact when the panels are open.

Numerals shall be white on a black background and shall be clearly defined.

Hour meters shall comply with the requirements specified in BS 89 for instruments of “Industrial Grade” accuracy.

Hour meters shall be suitable for a system voltage of 220 V, 50 Hz AC unless specified to the contrary. The meters shall be protected by HRC fuses.

39.12.2.24 Indicator Lights

Red indicator lenses shall generally indicate that the circuit is “ON” and green that the circuit is “OFF”.

All indicator lamps shall be clearly labelled.

39.12.2.25 Cable Gland Plates

Removable cable gland plates shall be provided on each panel and fixed by means of captive nuts or screws. The gland plates shall be located not less than 375 mm above floor level so that ample space is provided for the satisfactory making off of cables.

If gland plates are to be pre-drilled, drilling details shall be as provided in Section 38 – Electrical General.

All cable entries shall be from the bottom of the panel unless otherwise specified in Section 38 – Electrical General.

39.12.2.26 Motor Protection

Overload and single phase protection shall be provided for all motors. These devices shall have adjustable over current settings. The range of adjustment shall be at least 80% to 115% of normal full load current. The overload protection devices shall be suitable for all starting duties required.

Overload and single phasing relays shall be of the manual resetting type with reset buttons mounted in easily accessible positions.

(a) Motors rated up to 75 kW

All 3 phase motor starters shall be provided with thermal overload relays that are selected for each applicable motor rating.

The overload relays shall have inverse time current characteristics which comply with IEC 60947 trip class 10. Where motors have exceptional long starting times the trip class shall be selected to ensure that tripping doesn’t occur during motor starting.

The relay shall provide protection against:

- Single phasing;
- Phase reversal;
- Phase angle errors; and
- Unbalance supply voltage.

Where relays are mounted inside panels and the trip indicators on the relays are disabled due to the loss of control voltage when cubicle doors are opened, additional signal lamp indicators shall be provided on the cubicle doors otherwise the relays shall be flush mounted on the doors.

(b) Motors rated 75 kW and above

Motors larger than 75 kW shall be protected with electronic motor protection relays. The relay shall make provision for the minimum protection functions as follows:

- Thermal overload with thermal capacity memory;
- Unbalance current and single phasing;
- Phase sequence;
- Restart control (The cooling characteristics of the motor shall be accurately simulated to block starting until the motor has cooled down sufficiently for both hot and cold starts);
- Stall and jam protection;
- Earth leakage protection;
- Earth fault protection;
- Local / remote LED fault indication; and
- When earth fault and short circuit currents exceed the rupturing capacity of the contactors, trip signals shall be delayed by the motor protection relay to ensure that the fuses blow before the contactor is tripped.

39.12.2.27 Labelling

All MCCs and switchboards shall be identified with labels in accordance with the Drawings. The label shall have black characters at least 10 mm high on a white background.

All doors and removable covers shall be provided with a traffolite label on the outside, indicating the panel number or other identification. The label shall have black characters at least 10 mm high on a white background.

Warning labels shall be provided on all doors and removable covers where the apparatus contained inside the enclosure is alive when the door or cover is removed.

The warning labels shall be adequately sized and shall have red letters on a white background giving adequate warning to the operator or user that in the event of the door being opened or the cover being removed the apparatus contained inside the enclosure is alive and dangerous.

All components contained in compartments and panels shall be labelled with the same designations corresponding with those used in the schematic and wiring diagrams. These labels are required for recognition purposes and are to be engraved on traffolite labels. The size of these labels shall be to the discretion of the manufacturer but shall be easily identifiable.

All fuses including instrument fuses shall have labels stating function, fuse rating and duty or type where applicable.

Labelling shall be in English. All labels shall be fixed with screws or approved type rivets. Gluing on of labels will not be permitted unless approved beforehand by the Engineer.

Circuits shall be identified on a legend card which shall be installed on the inside of the door, or in any other position where it can conveniently be observed.

39.12.2.28 Control Circuit Voltage Supplies

The control circuit voltage supplies will be specified in Section 38 – Electrical General for the respective motor control centres required.

Where control circuit transformers are required, these shall be of the single phase double wound natural air-cooled type manufactured in accordance with SANS.

Where control transformers are required to be housed in compartments, the primary windings shall be connected to the main busbars via protective fuses and a suitable isolating switch. The secondary windings shall be connected to the control busbar or bus wire system by a protective device in the line side and an isolating link in the neutral. The central pole of the control circuit transformer shall be earthed.

Control transformers shall be rated at least 25% greater than the actual power requirements of the control circuit devices.

39.12.2.29 Isolators

All isolators shall be of the fault-make, load-break type and where used in combination with motor starters, shall be mechanically interlocked with the compartment doors to prevent the doors being open while the isolator is in the “ON” position.

39.12.2.30 Air Circuit Breakers (A.C.B.'s)

All air circuit breakers shall be of the withdrawable type unless otherwise specified in Section 38 – Electrical General. A.C.B.'s shall be provided with manual operating mechanisms and fitted with thermal overload protection devices as well as instantaneous acting protection responding to short circuit currents.

Air circuit breakers shall be installed in all circuits rated at 1000 ampere and greater.

39.12.2.31 Earthing

A continuous copper main earth bar shall be run for the full length of the switchboard or Motor Control Centre with a minimum cross sectional area of 70 mm^2.

All Plant requiring earthing shall be effectively earthed to this main earth busbar.

Manufacturers shall ensure that all cable gland plates are effectively earthed via the steelwork of the panel or provided with individual bonded conductors.

39.12.2.32 Shrouding

Shrouding shall be fitted to the following:

- To the live side of all isolating devices within each compartment or panel; and
- On all terminals which could become live due to back feeds from other starters or feeders.

All shrouds shall be of suitable insulating materials to the approval of the Engineer, and labelled where necessary.

More detailed descriptions of shrouding requirements will be given in Section 38 – Electrical General where necessary.

39.12.2.33 Painting and Protective Finishes

All painting and protective finishes shall comply with Section 37 – Painting and Corrosion Protection.

39.12.2.34 Inspection and Testing

The Engineer may carry out periodic inspections of the Motor Control Centres during various stages of manufacture.

Final factory tests of the Motor Control Centres shall be carried out before despatch from the Works.

All eight type of tests described in SANS 60439-1 Table 7 shall be carried out on each design of type tested assembly (TTA). Type tests on similar designs must form the basis of design verification for TTA's with stated deviations.

These tests shall include, but not be limited to, the following:

a) Tests to determine that the apparatus fully and strictly complies with the requirements of the Specification;

b) Comprehensive primary injection tests of all current transformers and associated circuitry;

c) Comprehensive pressure tests to prove insulation quality; and

d) Functional tests of all control gear and the feeders.

The Manufacturer shall make provision for all power supplies, testing Plant, simulating apparatus, and competent personnel to carry out the tests.

At least two weeks' notice of the manufacturer's intention to carry out final tests shall be given to the Engineer. All test results shall be recorded on standard test sheets and copies shall be provided to the Engineer within one week of satisfactory tests being completed.

Once Plant has been erected on Site, the following tests and field check-outs shall be performed:

- Random primary and injection tests to check that the functioning of control current transformers and associated circuitry has not been disturbed;
- Random checks on the functioning of control gear; and
- Comprehensive insulation resistance tests to prove that the quality of the insulation has not deteriorated during the installation of the Motor Control Centres.

Particulars of the Site tests and field check-outs and the results shall be recorded and incorporated on Site reports. Copies of the Site reports, signed by the Contractor, shall be provided for the Engineer.

Refer to Section 48 – Tests on Completion.

39.12.2.35 Drawings

(a) Drawings for Approval

A set of three prints of the shop drawings shall be submitted to the Engineer for approval before the boards are manufactured.

The following information shall be presented:

- A complete wiring diagram of the Plant on the boards;
- Schematic diagrams depicting all power and control circuits for each starter. The schematics shall be fully cross-referenced so that the inter-connection between all circuits may easily be determined. Also, the relationship with all external field devices and the PLC control;
- A complete termination diagram showing all the terminals and wiring detail;
- A complete layout and arrangement indicating all Plant dimensions and the constructions of the boards. The positions and methods of fixing busbars shall be shown;
- All labelling information on a separate sheet; and
- The make, catalogue number and capacity of all Plant such as isolators, circuit breakers fuses, contactors, etc.

The approval of Drawings shall not relieve the Contractor of his responsibility to supply the switchboards according to the requirements of the Specification and Drawings.

(b) Final Drawings

A complete set of “as-built” drawings shall be submitted to the Engineer immediately after completion of the Installation. Drawings shall be submitted as electronic copies on flash drives as well as paper copies.

(c) Manuals

Operating and Maintenance Manuals shall include the following information:

- Complete information on the operation of the Plant;
- Complete information for maintenance of the Plant;
- Brochures and ordering information, and
- A complete material list indicating quantities and relevant catalogue numbers.

39.12.2.36 Service Tools

A set of any special tools or devices required for the operation and maintenance of the Plant shall be provided complete with a suitable, lockable toolbox.

39.13 UNINTERRUPTABLE POWER SUPPLY (UPS)

39.13.1 Scope

The scope of this Clause includes the design, manufacture, testing at Works, supply and delivery of Uninterruptible Power Supplies (UPS).

The UPS shall be an on-line 3 phase in / 3 phase out type, unless otherwise specified in Section 38 – Electrical General.

39.13.2 Standards and Regulations

The UPS shall be housed in a freestanding enclosure. The enclosure shall be designed to blend into an IT environment. The cabinet shall be equipped for fork truck lifting. All service access shall be from the front. Installation access shall be from the lower backside of the system.

The UPS shall be in a self-contained cabinet and comprise 1 kVA, 5 kVA, 10 kVA, 15 kVA, 20 kVA, and 30 kVA power section; Bypass Static Switch; Battery for standard run time and interface LCD display all mounted in a separate cabinet. The UPS shall permit user installable and removable battery units.

The power section shall be of the Double Conversion On-Line topology with power factor corrected inputs. The UPS shall be capable of continuous operation at full rating without the temperature rise of any component or compartment exceeding the maximum recommended by the supplier of that Plant or those temperatures recommended by the relevant SANS, IEC or BS standard, whichever is the lesser, with the power supply and the environmental conditions specified hereinafter.

The UPS shall be capable of withstanding any combination of the following environmental conditions in which it must operate without mechanical or electrical damage, or degradation of operating characteristics.

a) **Storage Ambient Temperature:** -15°C to 40°C with batteries; -30°C to 70°C without batteries;

b) **Operating Ambient Temperature:** 0°C to 40°C. 15°C to 25°C is ideal for batteries (if above, the battery lifetime is reduced);

c) **Relative humidity:** 0 to 95%, non-condensing;

d) **Storage elevation:** 0 to 15000 m; and

e) **Altitude:** Maximum installation with no derating of the UPS above sea level shall be:

- 1000 m: 100% load;
- 1500 m: 95% load;
- 2000 m: 91% load;
- 2500 m: 86% load; and
- 3000 m: 82% load.

The UPS shall comply with the latest revision of the following standards:

- SANS 150: Insulated Wire;

- SANS 1474: UPS Units; and
- SANS 1652: Battery chargers- Industrial Type.

39.13.3 Power Supply Details

Refer to Section 38 – Electrical General.

39.13.4 Environmental Operating Conditions Rating

The UPS shall provide the rated power output for a maximum period of 30 minutes in the event of a loss of mains power, unless otherwise specified in Section 38 – Electrical General.

The UPS shall be able to boost charge discharged batteries and restore them to 95% of full charge within a period of 10 hours without affecting the output of the inverter.

39.13.5 Output Requirements

Output voltage regulation at unity power factor shall be +/-1% at steady load.

There shall be no rms deviation within 1 millisecond after application or removal of full load.

Nominal Output Voltage: 400/230 V.

Output Voltage Regulation for Steady State and Transient: ±1% steady state for static 100% balanced and unbalanced load.

Nominal frequency: 50 Hz ± 0.5% free running.

Nominal waveform: Sinusoidal.

Waveform distortion for any load from 0 to 100%, 3% maximum total harmonic distortion.

Overload capability:

a) 150% for 60 seconds in normal and battery operation;
b) 125% for 10 minutes in normal and battery operation; and
c) 110% continuous in bypass operation.

Load power factor: 0.8 lagging to 0.9 leading.

Efficiency: Input to output :> 85%.

Noise level: Less than 45 dBA.

39.13.6 Description

a) The UPS shall consist of the following easy to repair modular rectifier / inverter sections and easy to install internal and external modular battery units.
b) The UPS shall be provided with separate feeds for rectifier / inverter section and the static bypass switch.

c) **Modes of operation:** The UPS shall operate as an on-line system in the following modes:

i) **Normal:** The inverter and the rectifier shall operate in an on-line manner to continuously regulate the power to the critical load. The rectifier shall derive power from the AC input source and supply DC power to float charge the battery.

ii) **Battery:** Upon failure of the AC input source, the critical load shall continue being supplied by the inverter without any switching. The inverter shall obtain its power from the battery. There shall be no interruption in power to the critical load upon failure or restoration of the AC input source.

iii) **Recharge:** Upon restoration of the AC input source, the UPS shall simultaneously recharge the battery and regulate the power to the critical load.

iv) **Static Bypass:** The static bypass switch shall be used for transferring the critical load to input supply without interruption. Automatic re-transfer to normal operation shall also be accomplished with no interruption in power to the critical load. The static bypass switch shall be fully rated and shall be capable of manual operation. The UPS shall be able to recharge the batteries while supplying full power to the load via the static bypass switch.

v) **Internal maintenance bypass switch:** The UPS shall be provided with an internal manual bypass switch for supplying the load directly from the mains supply, while the UPS is taken out for maintenance. The switch should be removable when the individual UPS unit has to run in parallel with other units.

vi) **External maintenance bypass transformer [optional]:** The external Maintenance Bypass Panel shall be used for paralleling of multiple UPS units (optional for single UPS unit) to supply the load directly from the mains supply, if the UPS system has to undergo maintenance or service. An UPS input, output, common output and bypass breaker shall be housed in the same low-voltage assembly. The manual bypass breaker must be monitored by each UPS via an auxiliary contact. The Maintenance Bypass Panel must be housed in a wall mounted low-voltage assembly.

d) The UPS shall be provided with RS-232 signalling and WEB/SNMP integration. This system must provide a means for logging and alarming of all monitored points plus email notification.

e) The UPS shall have nominal voltage of 400/230 V (adjustable for 380/220 V, 415/240 V), 50 Hz, L1, L2, L3, N, PE.

f) The UPS will be capable of paralleling up to max 4 like kVA and type UPS systems for capacity.

g) The UPS shall be compatible with all types of data centres, data rooms and facilities. Dedicated service to one specific environment shall not be acceptable.

39.13.7 Component Requirements

39.13.7.1 Inverter and 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 DC 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.

The charger shall provide sufficient current to charge the batteries at “C over 10” rate for all input mains conditions down to – 15% of nominal input voltage.

The battery shall be kept in a fully charged state i.e. continuously floating across the charger.

The charger output voltage shall be isolated from the mains supply.

39.13.7.2 Batteries

The batteries shall be of the maintenance free type with a minimum battery life of 10 years under float conditions.

39.13.7.3 Inverter

The inverter shall consist of fast switching solid state power module. Inverter shall be PWM controlled using DSP logic. Analog control shall not be acceptable. The inverter modules shall be rated for an output power factor at 0.8.

Nominal output voltage shall be 1×230 V and adjustable for 1×220 V or 1×240 V, 50 Hz, L1,N,PE.

Efficiency of each module at full load: Not less than 95%.

Output Voltage Total Harmonic Distortion at full load

- Less than 1.5% for 100% resistive load.
- Less than 3.5% for computer load as defined by EN50091-3/IEC 62040-3.

Output Voltage Regulation

- **Static:** Less than 1% at full linear load.
- **Dynamic:** 5% at 100% step load.
- **Output frequency:** 50 Hz free running.
- **Crest factor:** Unlimited but regulates it down to 2.7.

Remote Emergency Power Off (EPO) shall be standard (wall switch and wiring shall be provided by the electrical contractor).

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 Contractor shall replace any thyristors or any inverter components at his own expense if these should be damaged upon installation.

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 semiconductor device 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 DC input to the inverter, which will discharge any capacitors in the inverter module when it is switched off.

39.13.7.4 Static Bypass Switch

The static switch shall consist of fully rated semiconductor device. Part rated solid state device with a wrap around contactor are not acceptable.

The static bypass switch shall automatically transfer the critical load to bypass input supply without interruption after the logic senses one of the following conditions:

- Inverter overload beyond rating;
- Battery runtime expired and bypass available;
- Inverter failure; and
- Fatal error in control system.

The static bypass switch shall automatically retransfer from bypass to the inverter, when one of the following conditions occurs:

- After an instantaneous overload-induced transfer has occurred and the load current has returned to less than 100% of the system rating;
- The static bypass switch shall be equipped with a manual means of transferring the load to bypass and back to inverter; and
- If more than 10 transfers from and to inverter occur in a 1 minute period, the load shall be locked on static bypass. An alarm communicating this condition shall be enunciated.

39.13.7.5 Rectifier

The input current limiter must be designed to support 100% load, charge batteries at 10% of the UPS output rating, and provide regulation with mains deviation of up/down to+/-15% of the nominal input voltage. During an overload condition the input current must be limited to maximum 125% of the nominal output current.

The DC buss voltage shall be compensated against temperature variations (Battery Temperature Compensation) to always maintain optimal battery float charging voltage for temperature excursions above or below 20°C. Temperature compensation rate shall be 320 mV/°C for ambient temperatures > 20°C and 0 mV/°C for ambient temperatures < 20°C.

DC ripple voltage shall be less than ±1% of nominal with no battery connected.

Input power factor shall be 0.98 lagging at 100% load without the use of passive filters.

Rectifier shall employ electronic waveform control technology to maintain the current sinusoïdal.

Pulse Width Modulation (PWM) current control shall be used. Digital Signal Processors.

(DSP) shall be used for all monitoring and control tasks. Analog control is not acceptable.

Reflected input current Total Harmonic Distortion (THD) shall not exceed 5% at 100% load.

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 semiconductor device housing, semiconductor device mounting, or on the heat sink close to the thyristor. The sensing of the off coming air temperature alone is not acceptable.

Contractors shall consider 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.

39.13.8 Protection and other Features

The UPS shall have surge protection fitted as specified in SANS 1474.

The AC input shall be protected by a circuit breaker on the following circuitry:

- Reserve (Static switch) input; and
- Rectifier / charger input.

The battery / rectifier shall be protected from inverter fault currents by a fuse and circuit breaker.

The inverter shall be protected by electronic current limiting and output circuit breaker.

The UPS shall have a static switch rated to supply full load continuously.

The static switch shall be capable of supplying 100% for 5 cycles in order to clear any type of load fault.

Automatic transfer of the load to the reserve input shall occur for loads in excess of 225% for 30 seconds, or on failure of the inverter. Transfer shall occur within 1 millisecond.

The static switch shall automatically transfer the load back to the inverter within one minute. If the load / inverter fault persists, the attempted transfer to inverter shall occur not less than three times, and not more than ten times, before locking on bypass.

39.13.9 Alarms

The UPS shall be fitted with the following alarms on the panel and facilities shall be provided for remote audible and visual indication of these alarms, either individually or grouped according to Clause 3.16.2 of SANS 1474:

a) Charger fail;
b) Battery over voltage;
c) Battery under voltage;
d) Battery low;
e) Battery warning;
f) Battery failure;
g) Battery Discharge;
h) Mains frequency out of range;
i) Load on bypass;
j) Inverter off. Load on reserve;
k) Inverter overload;
l) Inverter over temperature;
m) System not in sync;
n) Rectifier off;
o) Rectifier overcurrent;
p) Rectifier over temperature;
q) Reserve out of limits;
r) Static switch lockout;
s) Manual bypass on;
t) External over temperature;
u) Fan Fault; and
v) Output Overloaded.

A microprocessor controlled display unit shall be located on the front of the system. The display shall consist of an alphanumeric display with backlight, an alarm LED, and a keypad consisting of pushbutton switches.

39.13.10 Instrumentation

The following instrumentation shall be fitted on the UPS:

a) Output voltage indicator;
b) Battery voltage indicator; and
c) Output current.

39.13.11 Rating Plates

The UPS shall be fitted with a rating plate that shall provide the following information:

a) Rated mains voltage;

b) Rated inverter voltage;

c) Rated output current;

d) Nominal battery voltage; and

e) Rated power output.

39.13.12 Network Connectivity

The Ethernet Web/SNMP Adaptor shall allow one or more network management systems (NMS) to monitor and manage the UPS in TCP/IP network environments. The management information base (MIB) shall be provided in DOS and UNIX "tar" formats. The SNMP interface adaptor shall be connected to the UPS via the RS232 serial port on the standard communication interface board.

39.13.13 Unattended Shutdown

The UPS, in conjunction with a network interface card, shall be capable of gracefully shutting down one or more operating systems during when the UPS is on reserve mode.

The UPS shall also be capable of using an RS232 port to communicate by means of serial communications to gracefully shut down one or more operating systems during an on battery situation.

39.13.14 Software Compatibility

The UPS manufacturer shall have available software to support graceful shutdown and or remote monitoring for the following systems:

a) Microsoft Windows 95/98/XP.

b) Microsoft Windows NT 4.0 SP6/2000.

c) OS/2.

d) Netware 3.2 – 5.1.

e) MAC OS 9.04, 9.22, 10.

f) Digital Unix/True 64.

g) SGI 6.0-6.5.

h) SCO UNIX.

i) SVR4 2.3, 2.41.

j) SCO Unix Ware 7.0 - 7.11.

k) SUN Solaris 2.6-2.8.

l) SUN OS 4.13, 4.14.

m) IBM AIX 4.3x-4.33g, 5.1.

n) HP-UX 9.x-11.i.

39.13.15 Testing

The UPS shall be tested by the Contractor in the presence of the Engineer. The tests shall be in accordance with Clause 6 of SANS 1474.

Notice shall be given to the Engineer in writing before the commencement of the tests and test report in duplicate shall be forwarded to the Engineer within 7 days of the completion of these tests.

Failure of the UPS to meet the offered performance and characteristics may result in the rejection of the complete UPS.

39.14 BATTERIES, BATTERY CHARGERS AND DC DISTRIBUTION

39.14.1 Scope

This Clause covers the supply of battery tripping units for use with MV switchgear.

39.14.2 General

The station battery is required for permanent indoor installation to provide DC power supplies for:

a) Continuous and intermittent relay energising;

b) Continuous and intermittent alarm and position indication signalling;

c) Intermittent operation of tripping coils and contactors;

d) Intermittent operation of closing coils and contactors;

e) Intermittent energising of control circuits and interlocking circuits;

f) Continuous supervision of control and protection circuits;

g) Intermittent operation of motor-driven isolators and transformer tap changers;

h) Operation of emergency lights; and

i) Stand-by duties such as emergency operation of solenoid-operated switchgear.

Reliability of operation and full availability on demand at any time are of the utmost importance. The battery Plant shall operate unattended between scheduled maintenance intervals over a lifetime of at least 20 years.

39.14.3 Standards

The battery, battery charger(s) and associated Plant to be supplied against this Specification shall comply fully with the requirements of the latest edition of the following standard specification:

- NRS 026:1993 Battery charger – industrial type;
- SABS 156 Moulded-case circuit breakers; and
- IEC 60623 Vented nickel-cadmium prismatic rechargeable single Cells.

39.14.4 Electrical Conditions

- Tripping supply output voltage - Nominal 30 V DC.
- DC coil loading - 400 watts each.
- Number to be energised simultaneously - 6 coils.
- Duration of output pulse - 500 milliseconds.
- AC charger supply, selectable - 110 V, 1 phase
  - ± 10% 5 kA
  - 220 V, 1 phase
  - ± 10% 5 kA

39.14.5 Battery Chargers

39.14.5.1 AC Supply

Each battery charger shall be supplied from the selected three-phase station LV-AC distribution board. The battery chargers will normally be supplied from the main LV-AC-DB. It may as an alternative be fed directly off LV overhead lines which are exposed to severe lightning and switching surges. The AC input to the chargers shall thus be adequately protected.

A pilot light shall be provided on the charger to indicate when the AC supply to the charger is switched on. The pilot light shall preferably be of the LED type.

39.14.5.2 Battery Charger Requirements

Solid state microprocessor-controlled units will be acceptable. Contractors shall give full details of the units offered.

To facilitate equalising charging after a prolonged AC mains supply failure or charger failure, the charger shall be fitted with boost charging facilities which must be both manually initiated and automatically controlled, either by means of a timer or other suitable control circuitry. To prevent unauthorised operation of boost charging, the initiating device shall be concealed or shall be lockable. After elapse of the set boost charging time, the charger shall revert back to trickle float charging automatically. Boost charging must also have the facility to be able to be initiated externally via the SCADA system. The Contractor shall submit the charging regimes to be approved by the Engineer.

39.14.5.3 Charging Regime

The cells shall be charged by the float charge method, at a voltage to be recommended by the supplier. Current limiting of the charger shall be included to give overall recharging time from deep discharge condition of not more than 12 hours. Final charge voltage shall be selected to give a minimum gassing level commensurate with a slight positive pressure within the cell to reduce contact with outside air. Water loss should be minimal at the selected voltage.

Due cognisance shall be taken of any standing load. In any case, the charger must have reserve capacity to supply 2 amps continuous standing load during the entire charging period.

39.14.5.4 Charger Characteristics

Charger construction shall incorporate the following features:

a) Alarms as specified;

b) DC voltmeter;

c) DC ammeter;

d) Incoming supply circuit breaker;

e) AC supply live – neon indicator;

f) Automatic equalising charge cycle;

g) Automatic battery capacity test with manual override for spot check indication;

h) Ambient temperature / voltage compensation based on battery suppliers' published data;

i) Ripple content: less than 30% C3 current; and

j) The charger shall have built-in monitoring to prevent over-charging. The design should prevent a failure to boost charge as far as possible. Excessive voltage output should result in disconnection of the battery unit from the charger with a corresponding alarm.

39.14.5.5 Standing Loads

It should be assumed by the supplier that standing loads comprising microprocessor relays are in use. Consequently, the charger output should be equipped with suitable chokes and filters to obviate consequential damage to relays, both in the normal operating mode, and also in the event of disconnection of the battery load as a damping component.

39.14.5.6 Battery Management System

A battery management system shall provide the following:

a) Independent battery charging management;

b) Control operator intervention;

c) Charger boost control via SCADA and local controls;

d) Comprehensive alarm systems;

e) Charging currents from 5 A to 500 A;

f) Indication of DC and AC voltages and current;

g) Plug-in system;

h) Separate power supply has dual AC and DC input;

i) Continual battery monitoring after power failure;

j) Automatic calculation of AH capacity;

k) Controls two parallel chargers and loads; and

l) Charger protection.

Protection shall be achieved by a double pole moulded case circuit-breaker. In the case of 3-phase units, triple pole breakers shall be used. All circuit breakers shall be equipped with auxiliary contacts for alarm indication.

The charger shall be self-protecting against overload and external faults to the extent that accidental short-circuiting of the charger output terminals will not cause any damage to the charger. Current limiting in addition to protection devices such as breakers is preferred. The current limit shall be pre-settable from 5% to 100% of rated charger current.

A device shall be provided on the DC side of the charger to prevent the battery from discharging into the internal circuits of the charger in the event of failure of the DC output of the charger.

39.14.5.7 Alarms

The charger unit should provide a volt-free changeover contact wired to outgoing terminals and local LED indication for the following conditions:

High voltage alarm	:	If boost charge is sustained for in excess of 20 hours, high voltage alarm and battery disconnected from charger.
Low voltage / load test	:	At least once per day an automatic load test with low volt alarm is to be cycled, with battery disconnected from charger during test cycle.
Charger supply failed	:	Indicates failure of AC supply to battery.
Earth fault alarm	:	Indicates DC insulation resistance decreasing to below 100 k.ohm.

39.14.5.8 Output Facilities

Provision shall be made for four (4) output circuits, each individually switched via a suitable rated miniature DC circuit breaker. A 100A 100V diode shall be connected in series with the positive terminal of each output circuit.

39.14.5.9 Marking of Charger

Each charger shall clearly indicate the following information:

- Manufacturer’s name, type number and serial number;
- Float charging voltage at 25ºC;
- Number and type of cells;
- Current at current limit; and
- Supply voltages.

In addition a label detailing testing procedures and expected results is to be provided on the front panel of the charger. This should indicate how long the manual discharge test should be and what the healthy voltage should be after the discharge test. It should also tabulate a minimum voltage which indicates that the battery is in a poor condition.

39.14.6 Charger Cubicle

39.14.6.1 Construction

Approved vermin-proof ventilation shall be provided at or near the top and bottom of the enclosure. Combustible or flammable materials shall not be used in the construction of the enclosure excluding painting.

All cubicles shall be arranged for front access. Front access shall be by means of stiff side-hinged, lift-off doors which shall be lockable. In the case of a door, the door handle shall not stand proud of the cubicle.

Cubicles shall be spacious enough to permit full and easy access to all terminals and Plant mounted in the cubicle. However, the overall dimensions of any cubicle shall not exceed the following limiting dimensions:

a) Overall height 1,950 mm;
b) Overall length (dual chargers) 1,200 mm; and
c) Overall depth 600 mm.

All cubicles shall be provided with a brass earth terminal stud not less than 10 mm in diameter for earthing the cubicle.

39.14.6.2 Cable Gland Plate

The charger cubicle shall be arranged for bottom cable entry bearing in mind that a large number of cables are to be terminated. Suitable, removable gland plates of acceptable dimensions and located in approved positions shall be provided for glanding of incoming and outgoing cables. The gland plate shall consist of at least five removable sections mounted at 300 mm height from the ground, shall be freely accessible and no Plant shall be mounted within a distance of 300 mm above the gland plates in order to facilitate drilling of gland holes on site. Gland plates shall be left unpunched and the minimum thickness of the gland plates shall be 2.5 mm.

39.14.6.3 Earth Arrangements

All potential free metal parts in the charger shall be earthed to the cubicle which in turn shall be earthed to the substation earth for which an earthing stud is to be provided in the cubicle.

The metal screen between the primary and secondary windings of the rectifier transformer shall be earthed directly to the earthing terminal.

39.14.7 Battery

39.14.7.1 Battery Cells

Batteries shall be of the Nickel Cadmium (Ni-Cd) low-maintenance type designed for use in substations over long periods. The Contractor shall state what type of battery cell he is proposing, and what the expected life of a properly maintained battery would be. The Contractor shall further give details of the type of battery cell proposed.

Battery cells shall be housed in tough, transparent plastic or glass containers. The Contractor shall state what material the housings are made of.

All cells shall be supplied complete with electrolyte in a fully charged condition. The exterior parts of every cell shall be clean, dry and free from contamination. The supplier shall take the necessary precautions to prevent spillage of electrolyte or cell discharge during transit.

Each cell shall bear the manufacturer's name or trademark and the type number. In addition, every cell shall be marked permanently with an identification number for record purposes. The cells in each individual battery shall be numbered consecutively starting with no. 1 at the positive end. Identification marking of cells shall be to the approval of the Engineer.

The bank of battery cells shall be earthed in the centre. The poles of the battery shall not be earthed.

39.14.7.2 Battery Voltage

Throughout the lifetime of the battery the efficiency of a discharge – recharge cycle of the battery shall not fall below the following values:

a) Ampere-hour efficiency 90%.

b) Watt-hour efficiency 75%.

39.14.7.3 Intercell Connections and Terminals

Intercell connections shall preferably be flexible to some degree to prevent stress on cell terminals. Contractors shall state how this is achieved.

All batteries shall be supplied complete with all necessary intercell connections and with the necessary main terminal connections. Contractors shall submit their recommendations for connecting up separately mounted batteries with their respective chargers and shall quote for the supply of such connecting up Plant.

All intercell connections and main terminal connections shall be of the bolted type. Intercell connections shall be designed for low contact resistance throughout the lifetime of the battery. Unless otherwise agreed bolts and nuts used for intercell connections and terminal connections shall be made of lead, cadmium-plated phosphor bronze or stainless steel, and shall be free of anti-corrosive lubricants. Only flat washers shall be used.

39.14.7.4 Battery Accessories

If not specified elsewhere, each individual battery shall be supplied complete with the following accessories:

a) One syringe type hydrometers with a specific gravity scale range of approximately 1,100 to 1,300;

b) One electrolyte thermometer with a range of approximately 0 to 40 ºC; and

c) One cell bridging connector.

The price of the above accessories shall be included in the price of each complete battery.

39.14.7.5 Rating of Batteries

Battery capacities shall be a minimum of 10 amps hours at the 3 hour rate. In determining this rating, due cognisance shall be taken of the variation in ambient temperatures possible on Site and the resulting variation in cell voltage. It is therefore required that the specific amp hour rate shall be based on 80% of nominal cell capacity. Battery rating shall be based on a final voltage per cell of 1,1 volts.

39.14.7.6 Electrolyte Capacity

Cells are to remain maintenance free for many years. As an indication, the following parameters are considered reasonable:

- Water topping up - 4 years; and
- Electrolyte replenishment - 15 years.

Notwithstanding this requirement, electrolyte containers shall be based on a minimum capacity of 20 Ah cells, i.e. capacity of enclosure shall be at least double the rating of the cell plates.

39.14.7.7 Marking of Cells

Each cell shall clearly indicate the following information:

a) Polarity of terminals;
b) Electrolyte level – maximum and minimum;
c) Year of manufacture;
d) Manufacturer's name and batch number; and
e) Recommended expiry date (10 year effective life).

39.14.8 DC Distribution Boards

DC distribution board(s) incorporating the changeover switch equipped with the necessary busbars, busbar connections, DC circuit breakers, cable terminal blocks, labels and warning notices shall be provided for the distribution of the output of the battery/charger unit. The busbars and all "live" terminals shall be covered by a removable front cover plate to prevent accidental contact when doing switching.

Cubicles shall be spacious enough to permit full and easy access to all terminals and Plant mounted in the cubicle.

The two battery chargers are intended to be mounted side by side in the main control room. If required, the auto changeover system, as well as the manual changeover selector switch arrangement, as detailed below, can be housed in a separate cubicle (with limited width) mounted between the two charge cubicles. Full details are however required for final approval by the Engineer.

Provision shall be made to isolate the DC distribution board(s) from the battery / charger unit(s) by means of a double pole moulded case DC circuit breaker(s) of appropriate rating which will be installed between the selector switch and the outgoing DC circuit breakers.

39.14.8.1 Manual Changeover Selector Switch

A manual changeover selector switch for each charger and distribution board shall be integrated into each battery charger / distribution unit to facilitate the following switching:

a) Left hand position - DB one and DB two connected to charger one and battery one;
b) Centre position - DB one connected to charger one and battery one and DB two connected to charger two and battery two; and
c) Right hand position - DB one and DB two connected to charger two and battery two.

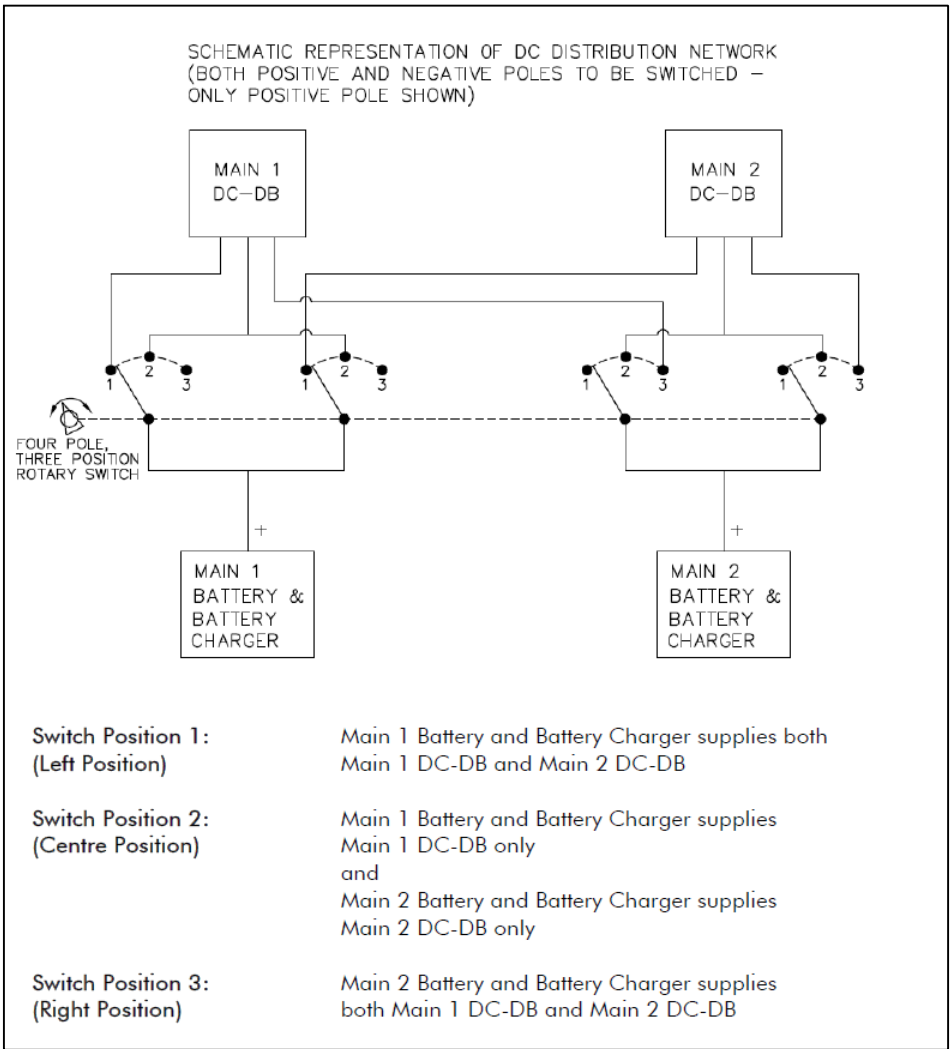
A three-position selector switch, without an “off” position shall be provided. Since both the positives and negatives of charger one and charger two distribution boards are to be switched simultaneously a 4-pole switch is required. This 4-pole switch must be “make before break” with diodes to prevent any voltage surges or dips during the changeover as well as any possible back feeds.

The changeover selector switch shall be an air-break, on-load switch complying with the requirements of SABS 152. The switch-chamber shall have a continuous load current and thermal current rating not less than 100 A at 250 V. The switch shall be rated for uninterrupted duty and for utilisation category DC-22 in terms of SABS 152.

The selector switch shall be of the spring assisted type, shall changeover by snap action and shall be arranged for independent manual operation. The switch shall preferably be of the rotating type and shall have wiping (make before break) type contacts. Plain contacts will not be acceptable.

The selector switch shall be fitted with bolted type terminals suitable for accommodating 25 mm² cable lugs. Terminal bolts shall be M16 minimum.

The changeover selector switch shall be fitted with a suitable and robust operating lever or handle preferably of the lever type equipped with padlocking facilities in each position. The coupling of fixing of the handle to the operating shaft shall be to the approval of the Engineer.



39.14.8.2 Wiring, Terminals, Ferrules

Wiring shall be colour coded and ferrule marked in accordance with BS 158 and such ferrule marking as may be shown on schematic diagrams that may be issued with the enquiry. For identification purposes identical ferrule markers of approved type shall be fitted to both ends of each wire. Ferrule markers shall be of a durable insulating material having a reasonable glossy finish to prevent the adhesion of dirt. Ferrule markers shall be marked clearly and permanently and shall not be affected by moisture, heat or battery acid. Unless otherwise approved, ferrule markers shall be white with black lettering.

All wiring shall be taken to terminals and wires shall not be jointed or teed between terminal points. Terminals shall be of the insertion double ended pinch bar type.

Terminals shall be suitable to accommodate at least two 4 mm² wires but not more than two wires shall be connected to an end of an insertion type terminal. Unless terminals were of the fully insulated type, suitable insulating barriers shall be provided between terminals. Terminal strips shall be suitably labelled, and terminals shall be numbered to facilitate identification. All terminal strips shall have a minimum of 20 % spare terminals.

39.14.8.3 Labels and Designation Plates

Labels shall preferably have black lettering on a white background, but danger plates and warnings shall have red lettering on a white background.

Suitable notices warning against malpractices such as incorrect operation of Plant, or any practice which may endanger the safety of the operator or other personnel, shall be provided when and as required. Such notices shall be to the approval of the Engineer in all respects.

Letter types and sizes for all labels shall be to approval.

Sufficient blank labels of the same type and size as that fitted on the board shall be supplied with the board for those positions where spare space for future possible circuit breakers have been called for.

In addition to a designation label for the changeover switch, the switch shall be equipped with labels corresponding to the switch positions tabulated below.

Manual changeover selector switch for dual charger and dual distribution boards:

- Left hand position - DB one and DB two connected to charger one and battery one;
- Centre position - DB one connected to charger one and battery one and DB two connected to charger two and battery two; and
- Right hand position - DB one and DB two connected to charger two and battery two.

39.14.9 Battery Stand Details

Battery stands shall be free-standing, compact design, strong, rigid and robust construction and suitable in every way for the lifetime support of the battery.

The battery cells shall be accessible from all sides, and not be mounted against a wall. It shall be possible to walk around the battery to have access to all cells. Adequate access shall permit ease of monitoring all cell electrolyte levels and also of testing SG values with a commercial hydrometer.

Unless otherwise approved, battery stands shall be constructed of plastic sections. All joints, voids and crevices shall be filled properly to prevent the ingress of electrolyte.

Maximum overall length of stand (regardless of single tier) single row or (double tier) double row shall not exceed 2,400 mm. Maximum overall height of double tier stand (excluding height of top tier batteries) not to exceed 1,250 mm. Maximum overall width of single row stand not to exceed 400 mm. Maximum overall width of double row stands not to exceed 850 mm.

Minimum clearance between the top of cells in bottom tier and the underside of the lowest support in tier above, shall not be less than 400 mm. Minimum height to the top of the bottom support from floor level shall not be less than 100 mm.

Double row stands shall either be level or terraced type. In the case of terraced type stands the difference in support levels between the front and rear row shall not be less than 100 mm and shall not exceed the height of a cell. The top of the battery shall not be higher than 1,500 mm. It shall in all cases be possible to see the whole end view of each battery cell so that any sediment will be clearly visible.

39.14.10 Installation

Installation shall include termination of interconnecting cable between charger and cells, intercell connectors and supply, installation and termination of a suitably rated cable of minimum size 10 mm² to the designated switchboard, (interconnecting distance shall be assumed to be less than 30 m, unless otherwise stated). Cabling shall be of the low toxicity (flame retardant) type and otherwise shall comply with SANS 1507 (blue stripe). Interconnecting cabling shall be steel wire armoured and shall be fixed in place using galvanised saddles at 800 mm intervals.

39.14.11 Tests and Certificates

39.14.11.1 Pre-commissioning Tests: Chargers

The following tests shall be carried out to prove the operation of the alarms and to determine current drain of alarm relays:

a) Voltage insulation test on transformer and wiring; and
b) Measuring of output ripple voltage and current.

39.14.11.2 Pre-commissioning Tests: Batteries

The Plant to be supplied shall successfully pass the following tests and/or shall be certified to have been successfully type tested in accordance with the specified requirements in the relevant test certificates:

a) Battery load test after installation;
b) Capacity test;
c) Suitability for floating battery operation;
d) Endurance discharge cycle test;
e) Charge retention test;
f) Short circuit current test; and
g) Impedance test.

39.14.11.3 Commissioning

Commissioning shall include checking terminations, filling the battery with electrolyte and tuning and setting of all charging functions to suit local ambient conditions and standing load requirements.

Refer to Section 48 – Tests on Completion.

39.14.11.4 Type Testing

Type tests shall be conducted to indicate the cell performance under the following conditions:

a) Maximum high rate discharge for 500 milliseconds at 25 ºC;
b) Voltage recovery time after maximum high rate discharge test at 25 ºC;
c) Above test to be repeated at 40 ºC ambient temperature;
d) Water consumption rate deduced from gas emission rate;
e) Current during maximum re-charge condition; and
f) A certificate detailing the results of the above tests shall be submitted to the Engineer.

39.14.11.5 Routine Testing

Following installation and commissioning, the following tests / checks shall be carried out:

a) Measurement of float voltage at full charge;
b) Measurement of float current at full charge;
c) Measurement of boost charge rate;
d) A one-hour discharge test at C3 rated current and measurement of final output voltage; and
e) A certificate detailing the results of the above tests shall be submitted to the Engineer.

39.15 DIESEL STANDBY GENERATOR

39.15.1 Scope

The scope of this section includes the design, manufacture, testing at Works, supply and delivery of a diesel standby generator.

39.15.2 Standards and Regulations

The diesel standby generator shall be designed to fully meet the requirements of the latest revisions and amendments of the following Standards:

NRS 024 Part 1	:	Diesel Alternator Sets for Fixed Installations
SANS 8528 part 1-12	:	Reciprocating internal combustion engine alternating current generating sets
IEC 60034-16	:	Rotating Electrical Machines – Part 16: Excitation System for Synchronous Machines
IEEE 112	:	Test procedures for Polyphone Induction Motors and Generators

IEEE 446	:	Recommended Practice for Emergency and Standby Power
SANS 10131	:	The Storage and Handling of Liquid Fuel
SANS 342	:	Automotive Diesel Fuel

39.15.3 General

A diesel standby generator shall be supplied and installed by the Contractor as shown on the Drawings. Room dimensions and openings shall be confirmed by the Contractor prior to ordering the unit. Should the opening sizes or the space available not be adequate for the generator offered, the Contractor shall advise the Engineer accordingly.

The generator size shown on the Drawings is for Tender purposes only. The Contractor shall confirm if the generator offered is sufficient to handle the volt drop and load specified.

The generator set shall be suitable for the ambient temperature and altitude as specified.

The installation shall in general comply with SANS 10142.

The generator shall be supplied, complete with a full tank of diesel and all the lubricants as required.

39.15.4 Design Criteria

The diesel standby generator shall meet the following general criteria:

a) Support a running load, as specified in Section 38 – Electrical General;
b) Support the load for a time period as specified in Section 38 – Electrical General;
c) Limit the voltage drop to 15% on all motor starts;
d) Provide remote automatic start-up on mains failure;
e) Have a noise level limited to 85 dBA at 5 metres; and
f) Be complete with suitable dummy loads.

39.15.5 Builder’s Work

The Contractor will be held responsible for any damage he causes to buildings and other services during the installation of the generator and shall immediately make good any such damage caused.

No cutting of structural concrete will be permitted unless the permission of the Engineer has been obtained beforehand in writing. The Contractor will be held responsible for any damage to the building due to non-compliance with this.

The Contractor shall take care that all pipes and other electrical Plant and accessories are firmly fixed in position in a manner acceptable to the Engineer.

The Contractor shall be responsible for making good all chases and openings in the building after the generator has been positioned and secured.

Immediately after award of the Contract, the Contractor shall inform the Engineer of the requirements for all chases and openings in the building and also at regular intervals thereafter to enable the Engineer to timeously amend structural requirements of the building before installation of the generator.

39.15.6 Electricity Supply

The electricity supply will be made available at the voltage specified in Section 38 – Electrical General and the Contractor shall deliver the installation in such a manner that it complies with the supply authority's requirements regarding voltage, current and frequency and with any other requirements which may be imposed by the supply authority.

39.15.7 Earthing

The entire installation shall be properly and effectively earthed and shall be bonded to the main earth bar by means of separate earth conductors.

All earthing work shall be executed before any painting commences.

39.15.8 Standby Generator Plant Layout

The standby generator set shall be installed in a standby generator room as shown on the Drawings.

The Contractor shall confirm that the space and ventilation openings provided are sufficient for the installation of the Plant as specified in Clause 39.8.5 above.

The general routes of exhaust pipes, fuel lines and cooling systems are to be confirmed with the Engineer.

The Contractor shall ensure that the access provided for the off-loading and placing into position of Plant is adequate. All Plant supplied shall be assembled to facilitate installation in and removal from the completed building.

39.15.9 Paintwork

After completion of erection, all painted parts shall be properly cleaned and painted with a final coat of good quality oil paint.

All surfaces subject to heat shall be painted with paint suitable to withstand the specific conditions.

The final colour of Plant and pipework will be as specified for the particular building. Colour codes shall be obtained from the Engineer in writing before final painting commences.

All paintwork shall comply with Section 37 – Painting and Corrosion Protection.

39.15.10 Name Plates and Notices

Name plates shall be to the Engineer's approval and shall be permanently mounted in suitable positions at the generator.

Name plates shall be manufactured from stainless steel plate. Letters and diagrams shall be engraved on the plate so that the continuous cleaning of name plates will not obliterate the information.

All valves, levers, meters, meter panels and other items used for the control of the generator set shall be supplied with name plates denoting the function and type of Plant.

39.15.11 Danger Notices

A clearly legible danger notice in bold red letters on a white background shall be mounted in a prominent position in the generator room.

The notice shall be made of a non-corrodible and non-deteriorating material, preferably engraved perspex and shall read as follows:

DANGER

THIS ENGINE CAN START WITHOUT NOTICE. TURN SELECTOR SWITCH ON CONTROL PANEL TO “OFF” BEFORE WORKING ON PLANT.

39.15.12 Diesel Engine

39.15.12.1 General

A naturally aspirated engine is preferred. Should the Contractor propose a turbo-charged engine, a written guarantee by the supplier that the turbo-charge engine will achieve the specified run-up time is required. Results of bench-testing of turbo-charged engines, of the type offered, shall be forwarded to the Engineer for approval.

The engine shall be completely self-contained and starting shall be possible without any external power assistance.

All auxiliary power requirements for the engine shall be supplied from the main alternator.

The engine shall be sized to drive an alternator with minimum alternator output as specified.

The stand-by generator set shall attain nominal running speed and deliver full rated output within 20 seconds of start-up.

The engine and alternator shall be coupled and mounted on a common base frame. The common base frame shall be attached by means of vibration dampers to a skid base. The skid base shall be installed directly on a solid concrete floor in the Plant room.

Oil-drip trays shall be supplied and installed under the engine.

Vibration Dampers shall be of the duplex type with cast iron protection caps.

39.15.12.2 Engine Speed

The maximum engine speed shall be 1 500 rpm.

A direct acting, mechanical speed controller shall be supplied with the engine. The controller shall stop the engine when the engine speed exceeds the allowable limit. The controller shall act directly on the fuel injection pump and not on the governor or the electric “stop” circuit.

39.15.12.3 Governor

The engine speed shall be controlled by a governor.

When full load is suddenly switched on or off, the momentary speed variation shall not be more than 10%. The permanent speed variation shall not exceed 4½% of the nominal speed.

External means shall be provided on the engines to facilitate adjustment of the nominal speed setting.

39.15.12.4 Starting

The engine shall be easily started from cold, without the use of any special ignition devices, during summer or winter conditions, against full load. The “run up” period from switch on until take-over of the full load, shall not exceed the time period specified above.

To ensure easy starting in cold weather, heaters may be installed in the engine sump. The heaters provided shall be completely automatic.

The electrical power for such heaters shall be taken from the control switchboard and shall be protected by a suitable circuit breaker. The Contractor shall submit his electrical requirements for heater circuits to the Engineer and obtain his approval prior to ordering the unit.

An electrical starter motor shall be fitted to the engine. Provision shall be made on the switchboard for both automatic and manual starting and stopping of the engine.

39.15.12.5 Cooling System

The engine shall be of the water-cooled type with a circulating water pump, radiator and cooling fan of sufficient capacity to ensure no overheating of the engine under normal operating conditions as well as when running at 10% overload for 1 hour.

The cooling system shall be pressurised and thermostatically controlled.

Protection against running at excessive temperatures shall be provided, with visual and audible alarms on the control panel in the event of overheating.

39.15.12.6 Lubrication System

The lubricant to main bearings and major moving parts shall be force-fed by means of a mechanically driven pump.

Manually lubricated moving parts of the engine shall be kept to the absolute minimum. The Contractor shall submit full details of the lubrication systems to the Engineer and obtain his approval prior to ordering the unit.

The engine shall be fitted with an automatic low oil pressure cut out device. Operation of this device shall give a visual and an audible indication on the control panel.

The engine-oil filter shall be of the rechargeable cellulose element type.

39.15.12.7 Diesel Engine Instrumentation

The following instruments shall be included with the diesel engine together with any other instruments which the Contractor may regard as essential for the efficient operation of the engine:

a) Tachometer with large and clearly legible dial graded at least up to 125% of normal speed;

b) A clearly legible lubrication oil pressure gauge indicating oil pressure close to the oil pump. The pressure indication shall be in kPa;

c) A temperature gauge indicating oil temperature in °C;

d) A temperature gauge indicating water temperature in °C;

e) A clearly legible pressure gauge indicating water pressure in kPa; and

f) An hour meter indicating the running time to at least one decimal place.

All the above instruments shall be mounted in such a way as to eliminate damage due to vibrations, and to eliminate damage during normal maintenance. Safe operating “zones” on meter dials shall be marked in green and danger operating “zones” shall be marked in red.

39.15.13 Fuel Tank

A fuel tank shall be installed in the same Plant room as the stand-by generator set.

The fuel tank shall be fixed or mounted in a rigid manner to the approval of the Engineer.

The capacity of the fuel tank shall be sufficient for at least twelve (12) hours continuous operation of the engine at 100% full load.

The fuel tank shall be supplied according to the following minimum requirements:

a) A double-skin fuel tank;

b) The capacity of the fuel tank shall not be more than 999 litres;

c) A drip-tray under the tank with sufficient area to cover the full volume of the tank and having a minimum depth of 100 mm;

d) A fuel level indicator. Glass tube indication will be accepted only if it is properly protected and of a thickness and construction that will prevent accidental breakage;

e) An electric pump, filtration system (water separation) and a drain plug provided at the lowest point on the tank to facilitate draining; and

f) A low-level alarm including circuitry giving indication and alarm on the control panel.

39.15.14 Exhaust Piping

Exhaust piping shall be supplied in flanged lengths manufactured from suitable gauge mild steel piping either seam or spiral-welded.

Flanged connections shall be made with suitable heat resistant gasket material.

All non-lagged sections of the exhaust system shall be painted with heat-resistant aluminium paint.

39.15.15 Expansion Pipes

Expansion sections shall be installed and so designed as to compensate for expansion and/or contraction of the exhaust system. The Contractor shall provide all necessary anchor points.

39.15.16 Hangers, Supports and Guides

Hangers, supports and guides shall be suitably fixed to the structure to allow for any expansion and/or contraction of the exhaust system.

The exhaust system shall be supported in such a manner as to ensure that no vibration is transmitted to the building structure.

The Contractor shall submit full details of the exhaust support system to the Engineer for his approval.

39.15.17 Insulation

All sections of the exhaust system within normal reach shall be thermally insulated with an approved material to ensure that a maximum surface temperature of 60 °C is not exceeded under worst conditions.

39.15.18 Weather Protection

All exposed exhaust system outlets shall be supplied with suitable weather protective hoods.

39.15.19 Alternator

39.15.19.1 General

The alternator shall conform to the following:

a) Output 415 volt, 3 phase, 50 Hz with neutral;
b) Overload capacity to suit the engine;
c) Insulation: Class H;
d) Excitation: self-exciting brushless type;
e) Housing: drip-proof; and
f) Ventilation: natural, without the use of external fans.

The alternator shall be capable of the maximum rating as specified under the worst conditions specified herein.

The design shall ensure a sinusoidal voltage wave form within the allowed tolerances.

The terminals shall be marked and the phase rotation shall be according to the standard phase rotation of the local supply authority.

The windings shall be properly wedged to eliminate damage or movement during faults or surges.

Windings shall be so arranged as to facilitate the replacement of faulty coils.

Non-hygroscopic material shall be used for all spacers, wedges and clamps.

The neutral shall be bonded solidly to the main earth system and the alternator connected to the distribution board by means of a four-core cable.

Radio and television transmission interference shall be minimal and suppression shall be in accordance with BS EN 55014.

39.15.19.2 Voltage Regulation

The alternator shall be self-regulated and the voltage shall automatically be regulated as follows:

- Within +10% of nominal voltage under all load conditions with power factors between unity and 0.8 lagging; and
- Within the driving speed variations, between no load and full load, corresponding to the diesel engine speed regulation.

The voltage shall recover to within 10% of the nominal voltage within 300 ms, following the application of full load. Transient voltage dip shall not exceed 15%.

39.15.19.3 Alternator Protection

The Contractor shall ensure that adequate protection is provided for the Plant offered, whether or not such protection is specified.

The Contractor shall include any protection in addition to the specified protection which is regarded by the Contractor's designer as essential for the safe working of the Plant.
The following protection shall be supplied:

a) Over current protection;

b) Earth fault protection;

c) Differential protection;

d) Over voltage protection;

e) Under voltage protection;

f) Over speed protection;

g) Under speed protection; and

h) Reverse power protection.

39.15.20 Electrical System

39.15.20.1 General

The generating set shall automatically start and supply power to the stand-by installation in the event of a power failure. On restoration of normal power, the generating set shall automatically shut down.

The facility for manual operation of the generating set for test and other purposes shall also be provided.

39.15.20.2 Protection and Alarms

A microprocessor based monitoring, metering and control system shall be provided.

Provision shall be made for the following alarms and actions. The Contractor may provide additional alarms that he considers to be necessary. A reset push button shall be provided to cancel a visible alarm only when the fault has been cleared.

TABLE 39/2
ALARMS AND ACTIONS

FAULT	ACTION	VISIBLE ALARM
High water temperature	Stop engine	Yes
High engine temperature	Stop engine	Yes
Low oil pressure	Stop engine	Yes
Overspeed	Stop engine	Yes
Underspeed	Stop engine	Yes
Overvoltage	Trip circuit breaker	Yes
Undervoltage	-	Yes
Reverse power	Trip circuit breaker	Yes
Engine shut down failure	-	Yes
Engine start failure	-	Yes
Overload	Trip circuit breaker	Yes
Earth fault	Trip circuit breaker	Yes
Low fuel level	-	Yes
Low battery voltage	-	Yes
Battery charger out of order	-	Yes

All alarms shall be wired to a terminal strip inside the control panel and cabled to the PLC marshalling cubicle.

39.15.20.3 Start and/or Stop Control

A four position (OFF/MANUAL/AUTOMATIC/TEST) selector switch shall be provided on the control panel.

The selector switch shall be lockable in each position and shall function as follows:

a) “OFF” Position

In this position starting of the generating set either manually or automatically, is prevented.

b) "MANUAL" Position

In this position the generator starting and power change over sequence shall be started and stopped via a local start and stop pushbutton.

c) "AUTOMATIC" Position

In this position the generator starting and power changeover sequence shall be initiated automatically from a remote signal.

d) "TEST" Position

With the selector switch in this position and the "start" push button depressed, the generating set will start. The output contactor will be prevented from operating and shall remain in the open position.

Should a "run down" period be necessary, the generating set shall stop immediately upon the depression of the "stop" push button.

e) "START" and "STOP" Push Buttons

"Start" and "Stop" push buttons shall be provided and clearly marked on the front of the generating set's control panel.

The "Start" and "Stop" push buttons shall only be operative with the selector switch in the "manual" or "test" position.

39.15.20.4 Output Control

The operation of the output contactor shall be fully automatic and as described below.

On normal power supply failure, the generating set shall start, and as soon as stand-by power at the rated voltage is available at the output of the protection circuit breaker, the output contactor shall close and power will be available on the output terminals or busbar.

The output contact will open once normal supply is restored and an adjustable time delay has operated.

39.15.20.5 Diesel Engine Starting Batteries

A fully charged 24 or 32 volt lead acid battery pack shall be provided with the generating set.

The battery pack shall be rigidly mounted adjacent to the generating set in a suitable robust battery rack.

The battery pack shall have ample capacity for six successive starting attempts.

Battery guarantees shall be handed over to the Engineer after the Tests on Completion.

39.15.20.6 Battery Charger

The starting batteries shall be charged by means of a brushless alternator / rectifier with automatic charging current regulation driven by the engine when operating.

An automatic battery charger with high and low charging rates shall be provided for charging when the engine is not operating.

The battery charger supplied shall be suitably rated to recharge a completely discharged battery within a maximum period of 12 hours, as well as providing a permanent trickle or maintenance charge.

39.15.20.7 Control Panel

An integrated microprocessor based control panel, for monitoring, metering and control shall be provided. The control panel shall be situated in the same Plant room as the generating set.

The section of distribution board accommodating circuits on standby supply shall be mechanically and electrically separated from the normal section.

All relays and contacts used in normal/standby changeover circuitry shall be electrically and mechanically interlocked to prevent the parallel connection of the two different supplies.

The control panel shall house the following:

a) All alarms, indicating lights and control switches;
b) All control circuits and gauges for the diesel engine;
c) All switching circuits for the diesel engine;
d) All control circuits for the alternator;
e) All circuits and meters not specified above but necessary for the correct and safe operation of the generating set;
f) An ammeter indicating current output as a percentage of maximum rated standby current (Scale 0-125%);
g) A voltmeter, indicating output voltage of the alternator;
h) Power factor metering and indication;
i) Frequency metering and indication;
j) An hour meter;
k) Battery voltage indication; and
l) Battery charging current indication.

39.15.21 Tests

A full set of Type Tests shall be submitted by the Contractor. The type tests shall be in accordance with SANS 8528-6.

The following tests shall be performed and test results shall be submitted to the Engineer within 7 days after completion of the tests. The tests shall be in accordance with SANS 8528-1.

- Insulation Resistance Test;
- Operational Works Test; and
- Site Tests.

The Engineer shall be informed in writing 14 days before testing commences to allow him to arrange to witness the tests.

39.15.22 Instruction Manuals

A preliminary set of instruction, service and maintenance manuals are to be submitted to the Engineer before installation commences.

The manuals shall include the following:

- Full electrical and mechanical operating instructions;
- Diagrams, drawings, etc., to facilitate servicing, maintenance and fault finding of the complete generating set; and
- A complete list of spare parts with descriptions and suppliers.

The Contractor shall hand to the Engineer complete sets of Final Instruction Service and Maintenance Manuals and Drawings after the Tests on Completion. Refer to Section 48 – Tests on Completion.

The installation shall be considered incomplete until such time that all the above requirements have been met.

39.16 LOW VOLTAGE INDUCTION MOTORS

39.16.1 Scope

This Clause defines the design, manufacture, inspection, testing and delivery of low voltage single speed, three phase, AC, induction motors.

39.16.2 General

Motors shall have a maximum continuous rated output not less than 20% above the maximum operating load, after site derating.

If thermistor or RTD winding protection is used, the maximum continuous rated output of the motor shall be not less than 10% above the maximum operating load.

Motors greater than 45 kW and variable speed drive motors shall be fitted with thermistor over-temperature protection and be rated accordingly.

Motors to be used in conjunction with variable speed drives (VSD) shall be further derated as necessary to account for harmonic currents and low speed operation. The rating of motors shall be determined in accordance with the variable voltage, variable frequency (VVVF) drive manufacturer's recommendation.

Motors shall be a Type Tested standard product design, from a recognised electric motor manufacturer with an accredited Quality Management System to ISO 9001 or equivalent.

39.16.3 Standards

The motors shall comply with the requirements of the following standards:

SANS 1804 part 1-2 : Induction motors

SANS 60034 (relevant parts) : Rotating electrical machines.

Where motors are to be controlled by VSD's, particular attention must be given to parts 17 and 31 of SANS 60034.

39.16.4 Rating

The motors shall have maximum continuous rated outputs for an S1 (Continuous running duty) classification of duty in accordance with SANS 60034.

39.16.5 Method of Starting

The motors shall be suitable for full voltage starting direct on line (DOL) or via VSD.

39.16.6 Power Factor

Power factor of the motors shall not be less than 0.8 at ¾ full load for motors rated greater than 30 kW.

39.16.7 Efficiency

Motors shall be of a high efficiency design, with a minimum efficiency, 1E2, at full load not less than the following values:

TABLE 39/3
MINIMUM MOTOR EFFICIENCY (%)

RATED kW	4 POLE	6 POLE	8 POLE
0.75	74	71	63
1.1	78	74	65
1.5	79	78	70
2.2	81.5	81	75
3	84	83	80
4	86	84.5	82.5
5.5	86.5	86	83.5
7.5	88	87	84
11	89	88	88
15	90	90	88
18.5	90.5	89	88.5
22	91.5	90	90
30	92.5	90	91

RATED kW	4 POLE	6 POLE	8 POLE
37	93.5	93	92.5
45	94	94	94
55	93.5	94	94
75	95	94	95
90	94.5	95	95
110	95.5	95.5	94.5
132	95.5	95.5	95.5
150	96	96	96

For a VSD controlled motor, an alternative motor efficiency shall be accepted if the Contractor can demonstrate that the motor is more efficient at the duty of the variable speed drive than the efficiency specified above.

39.16.8 Thermistors and Temperature Sensors

All motors rated greater than 45 kW shall have 2 temperature sensors embedded into each phase of the three stator windings. Temperature sensors shall be of the 100 ohm (at 0°C) platinum resistance detector type (RTD), or shall be of the positive temperature eco efficient (PTC) type.

The requirements for each motor shall be provided in the Section 38 – Electrical General.

Thermistor connections shall be brought out to terminals in the main terminal box or a separate terminal box.

39.16.9 Enclosure

Motors shall have a degree of protection of at least IP54.

39.16.10 Cooling

Motors shall be fan cooled.

When controlled by a VSD, the motor cooling shall be designed for the load and the lowest duty speed at which the motor will operate.

39.16.11 Motor Terminal Box

The motor terminal box shall be located on the right side of the motor when viewed from the drive end. The motor terminal box shall be arranged for cable entry from any of four directions.

39.16.12 Insulation

Motor winding insulation shall not be lower than Class 155 (F). Temperature rise shall not exceed Class B limits.

39.16.13 Bearings

Bearings shall be sealed and shall have a nominal life rating of 60 000 hours.

The bearing system of motors with vertical shafts shall be capable of carrying an axial thrust equivalent to not less than twice the weight of the rotor.

For motors with horizontal shafts, the bearing system shall be capable of carrying sufficient axial thrust to allow the motor to be run disconnected from the load.

39.16.14 Fans

Motors shall be fitted with bi-directional fans where practical.

39.16.15 Lifting Eyes

Motors shall be supplied with lifting eyes to enable each motor to be lifted by an overhead crane. The lifting eye shall be suitably rated for the mass of the fully assembled motor.

39.16.16 Nameplates

Motors shall be fitted with the following stainless-steel nameplates:

- Motor rating plate with a unique serial number; and
- Temperature sensor data plate, including the manufacturer, type number, tripping temperature, resistance of each sensor at the tripping temperature, and the number of sensors embedded per winding.

39.16.17 Factory Tests

Motors shall be subjected to routine tests and a copy of the test certificates shall be supplied to the Engineer, within 7 days of the test.

The Engineer shall be informed in writing 14 days before testing commences to arrange to witness the tests.

39.17 MEDIUM VOLTAGE INDUCTION MOTORS

39.17.1 Scope

This Clause defines the design, manufacture, inspection, testing and delivery of medium voltage, three phase, AC, induction motors.

39.17.2 General

The maximum continuous rated output of the motor shall be not less than 10% above the maximum operating load, after site de-rating. Site conditions are specified in Section 38 – Electrical General.

Motors to be used in conjunction with variable Speed drives (VSDs) shall be further de-rated as necessary to account for harmonic currents and low speed operation. The rating of motors shall be determined in accordance with the VSD manufacturer's recommendation. Generally, it is required that the variable frequency converter, and associated drive motor be provided by a single manufacturer as a complete unit.

The motors shall comply with the requirements of the following standards:

SANS 1804 part 1-2 : Induction motors
SANS 60034 (relevant parts) : Rotating electrical machines

Where motors are to be controlled by VSDs, particular attention must be given to parts 17 and 31 of SANS 60034.

Motors shall be of a type-tested standard product design from a recognised electric motor manufacturer with an accredited Quality Management System to ISO 9001 or equivalent.

Motors shall have a design life of 20 years subject to maintenance.

The power supply detail is as specified in Section 38 – Electrical General.

39.17.3 Starting Characteristics

Motor starting method shall be as shown on the Drawings or indicated in Section 38 – Electrical General.

The motor starting torque, with the appropriately matched starter in circuit, shall be suitable for the mechanical load. Motor torque speed characteristics and locked rotor characteristics shall be as included in the returnable Technical Schedules.

The motor current drawn from the supply with the appropriately matched starter in circuit shall not exceed the value stated in Section 38 – Electrical General.

From steady state rated load (hot) conditions, the motor shall be capable of two starts per hour, without any cooling period between starts.

39.17.4 Standards

The motors shall comply with the requirements of the following standards:

SANS 1804 part 1 : Induction motors
SANS 60034(relevant parts) : Rotating electrical machines
SANS 60072 : Dimensions and output series for rotating electrical machines

Where South African Standards, Codes and Regulations do not exist, those of International Standards Organisation (ISO) or other standards shall apply.

39.17.5 Rating

The motors shall have maximum continuous rated outputs for an S1 classification of duty in accordance with SANS 60034.

39.17.6 Method of Starting

Motors shall be suitable for full voltage starting direct on line (DOL) and VSD operation.

39.17.7 Resistance Temperature Detectors (RTDs)

RTDs shall be provided as follows:

- 2 per phase winding (1 used, 1 backup); and
- 1 per bearing.

RTDs shall be platinum and have a resistance of 100 ohms at 0º C. The RTD elements shall be of the 3-wire type and individually connected to a separate termination box. The RTD termination box shall be fitted with a stainless-steel plate engraved with the legend 'RTD Terminals - DO NOT MEGGER'.

RTDs shall be fitted prior to the impregnation of the windings.

RTD elements shall be provided with short circuit type over voltage surge diverters installed in the RTD terminal box.

39.17.8 Stator Frame and Enclosure

Motors shall be constructed using all metallic components. Non-metallic, aluminium or aluminium alloy materials shall not be used.

Motors shall have a degree of protection of at least IP54.

Motor frames, enclosures, and heat exchanger shall be cast iron or steel. Dissimilar metals which may cause corrosion shall not be used. Protective screens for cooling air inlets shall have a minimum mesh of 6 mm with a minimum thickness of 1 mm.

The stator core shall be constructed of 230 grade low magnetic loss steel with a maximum thickness of 0.5 mm.

The stator frame shall be reversible to permit relocation of the stator terminal box.

Motors, and any removable component in excess of 25 kg shall be provided with eye bolts for hoisting.

An external earthing terminal with a minimum current carrying capacity of at least half the current capacity of the stator terminals shall be fitted on each motor. The earthing terminal shall be suitable for terminating a 120 mm2 copper conductor using a crimp lug with a 12 mm diameter hole.

39.17.9 Cooling

Motors shall be water cooled unless otherwise specified in Section 38 – Electrical General.

When controlled by a VSD, the motor cooling shall be designed for the load and the lowest duty speed at which the motor will operate.

39.17.10 Motor Terminal Box

The motor terminal box of a motor shall be located on the right side of the motor when viewed from the drive end. The motor terminal box shall be arranged for cable entry from any of four directions.

39.17.11 Insulation

Motor winding insulation shall not be lower than Class 155 (F).

Windings shall be suitable for switching with vacuum or SF6 type contactors and/or circuit breakers.

Motors which have a supply that is not effectively earthed, or is resistance earthed, shall have a phase-to-earth insulation rating not less than the supply phase-to-phase voltage rating.

39.17.12 Anti-Condensation Heaters

An anti-condensation heating system rated at 240 volts shall be provided for each motor. The terminal box shall be fitted with an engraved traffolyte warning label with the following warning:

DANGER THIS CIRCUIT IS LIVE WHEN MOTOR IS ISOLATED

39.17.13 Bearings

Motors shall be equipped with grease lubricated deep groove ball bearings. However, for special drives with high radial forces, the application of roller bearings or a combination of ball and roller bearings at the drive end may be used.

The minimum re-lubrication interval shall be 4 000 hours. Re-lubrication shall be possible while the motor is running.

The bearing housing shall be equipped with a pressure relief device which ensures that the new grease displaces the maximum amount of old grease and automatically ejects any surplus to the outside of the casing. Suitable seals shall be provided with a rotating barrier plate to prevent entry of moisture and dust.

Bearings shall be provided with testing points for shock pulse measuring (MEPA 10 studs). Each bearing shall be furnished with a PT-100 RTD such that the sensor, in the case of rolling element

bearings, makes contact with the outer race or, in the case of sleeve bearings, is as close as possible to the loaded area of the white metal.

Motors may be fitted with sleeve bearings if this is recommended by the motor manufacturer. These bearings shall be fitted with labyrinth type seals to exclude dirt and retain the lubricant.

Products used for the protection shall be readily removed without damage to the bearing.

A complete, self-contained forced oil lubrication system shall be provided with sleeve bearings. The system shall include, but is not limited to, the following:

a) Oil pump, backed up by a standby pump, and pressure-limited;

b) Magnetic separators in the oil supply line;

c) Oil inlet pressure gauge for each bearing inlet;

d) Oil discharge temperature sensor at each bearing;

e) Valves, piping, reservoirs;

f) Filtered oil cooler;

g) Oil cooling system, if necessary, for the Site conditions; and

h) Oil heating system, if necessary, for the Site conditions.

Where forced lubrication is required, details of this shall be submitted to the Engineer for approval.

Bearings shall have a nominal life rating of at least 60 000 hours.

The bearing system of motors with vertical shafts shall be capable of carrying an axial thrust equivalent to not less than twice the weight of the rotor.

For motors with horizontal shafts, the bearing system shall be capable of carrying sufficient axial thrust to allow the motor to be run disconnected from the load.

Bearings for motors, supplied with electronic VSDs and soft starters, shall be insulated or be provided with a grounding device. An insulated coupling with the driven load shall also be used.

39.17.14 Lifting Eyes

Motors shall be supplied with lifting eyes to enable each motor to be lifted by an overhead crane. The lifting eye shall be suitably rated for the mass of the fully assembled motor.

39.17.15 Terminal Boxes

All terminal boxes shall provide a minimum degree of protection of IP56, using only whole piece gaskets. They shall be of robust construction and be of ample size to allow free and easy access to the terminals for terminating the cables shown on the Drawings or specified in Section 38 – Electrical General.

Facilities shall be provided for glanding cables. Each box shall be fitted with an internal earth stud for connection of the cable screens.

39.17.16 Nameplates

The motor shall be fitted with the following stainless-steel nameplates:

- Motor rating plate with a unique serial number; and
- Temperature sensor data plate, including the manufacturer, type number, and the number of sensors embedded per winding.

Rating plates shall be attached with stainless steel screws and shall be fixed to the motor housing and not to terminal box covers.

39.17.17 Factory Acceptance Inspection and Testing

Motors shall be subjected to routine tests and a copy of the test certificate shall be supplied together with any type testing certificates on similar motors.

A factory acceptance inspection and test plan program shall be submitted to the Engineer for approval.

Motors which are to be used with VSDs or soft starters shall be tested as a complete installation, i.e. motor starter, motors and mechanical Plant. The complete installation shall be run at various loads and speeds, if applicable.

Testing of the complete installation shall be witnessed by the Engineer.

39.17.18 Installation and Commissioning

Detailed instructions, procedures, plans and other documentation shall be provided in such detail to allow installation and construction by others.

39.17.19 Spare Parts

A spare parts list including the following shall be provided:

- Commissioning spares; and
- Operating spares.

39.18 LOW VOLTAGE VARIABLE SPEED DRIVES (VSD)

39.18.1 General

Scopes of Works

The scopes of work shall be for the supply, factory acceptance testing (FAT), delivery, installation, site acceptance testing (SAT) and commissioning of the Plant and/or materials.

39.18.1.1 Electrical Characteristic

The VSD unit is to be designed and built specifically for fan and pump operation.

The VSD is to be suitable for controlling the speed of standard three phase 380 V – 415 V induction motors.

The VSD is required to operate continuously at full load rating of the driven motor with variations of ±10% of the supply voltage and ±2% of the supply frequency.

Unless otherwise stipulated on the submitted application VSD data sheet, the control supply for all AC-VSD shall be confirmed with the engineer before ordering Plant.

Unless otherwise stipulated on the submitted application VSD data sheet the rated supply frequency will be 50 Hz, but AC-VSD must maintain normal operation and full output for frequency variations between +4% and -4% of the rated value.

Unless otherwise stipulated on the submitted application VSD data sheet, the output frequency of the converter should be in the range of 5 to 75 Hz, and the 3-phase output voltage should be a nominal 400 volts at 50 Hz.

The rated power converter will be specified on the application VSD data sheet and refers to the maximum continuous power output of the converter when running at an output frequency of 50 Hz.

The rated short time withstand current will be specified on the submitted application VSD data sheet and refers to the RMS value of the current which can be drawn from the AC supply in the event of a short-circuit within the converter. The Peak value of this current can be taken to be 2.5 times the RMS value.

Unless otherwise specified on the submitted application VSD data sheet, AC-VSD must withstand the passage of this current for a period of not less than ONE SECOND without sustaining any permanent damage or degradation of performance.

Unless otherwise stipulated on the submitted application VSD data sheet, the neutral point of each converter transformer will be earthed via a resistor having an ohmic value of 30. The maximum value of earth-fault current for a phase-to-phase potential of 400 volts will thus be a nominal 10 amperes

The VSD is required to operate continuously at full load in an ambient temperature of 38°C unless otherwise stipulated on the submitted application VSD data sheet.

The VSD is to be manufactured to quality standards according to ISO 9001.

39.18.1.2 Construction

All materials used shall satisfy the relevant SANS and other Standard Specifications and may only deviate from it upon a definite instruction in this specification. The successful Tenderer shall ensure that he possesses the latest edition of the relevant Specifications as listed in this specification.

As a general rule, the overall height of the panel(s) housing the converter(s), including any plinth at the base, should not exceed 2300 mm. Other dimensions are normally left to the discretion of the manufacturer, subject to him submitting a preliminary drawing for approval at the time of tender.

However, if conditions at site require any or all dimensions to be limited, then such limitations will be stated on the submitted application VSD data sheet.

Unless otherwise stipulated on the ADS, the material used for the construction of the convertor panels should be mild steel sheet of not less than 2mm in thickness. The method of construction should be either;

a) By folding and welding. If this method is used, then all corner gaps due to folding should be fillet welded and dressed flush and smooth. Other weld areas should be removed and all surfaces, both internal and external, should be free from blemishes before painting;

b) By assembly of prefabricated parts. If this method is used then only good quality, plated, nuts and bolts should be used to join the parts together or to a supporting structure. No self-tapping screws or pop-rivets may be used for this purpose; or

c) By a combination of the above.

It is essential that well-designed jigs are used to ensure accurate shaping and dimensioning of each panel. It is also essential that the design of the panels should be such that the stresses incurred during lifting, loading, transport to site, and off-loading, do not result in any permanent distortion, so that when the individual panels are erected on site a properly aligned assembly of good appearance results.

The paint systems acceptable to Contractor are, in order of preference:

- Epoxy Coating;
- Baked Enamel; and
- Air-drying Enamel.

Because of the multiplicity of paint systems standardised by the various manufacturers, no rigid painting requirements are laid down here. At the time of tender, manufacturers must detail the paint system they offer, bearing in mind the preferences expressed above. The information given must include details of the processes of cleaning, degreasing, priming, undercoating, and final finishing. If the Contractor considers the system offered to be unacceptable, then they reserve the right to require the manufacturer to offer a better system at the same price, failing which the tender may be rejected.

39.18.1.3 Electrical Safety

The VSD is to have all necessary WARNING or CAUTION notices permanently fixed to the VSD and VSD enclosure.

The VSD is to be suitable for service in mechanical plant rooms where dust, moisture and water is present. A minimum enclosure protection to IP54 rating is required. The VSD is to be mounted in a ventilated area allowing the dissipation of heat energy.

The VSD is to be suitable for switching on the output side. Motor reactors limiting the rise time of the current are a minimum requirement and are to be integral with the VSD.

Isolation of the mains supply to the VSD and from the VSD to motor is a requirement to allow for safe maintenance, repair and to prevent motor operation during set up procedures.

39.18.1.4 Galvanic Isolation

The VSD is to provide isolation between the control and power circuits to ensure dangerous voltages cannot be transmitted to control signals. This isolation is to be integral with the VSD and capable of withstanding a test voltage of 2.5 kV for 1 second.

39.18.1.5 Mains Supply

The VSD is to incorporate all necessary chokes, filters, capacitors and motor coils to reduce and limit radio frequency interference and harmonics to a level which does not interfere with other Plant on the same power supply.

The VSD is to incorporate harmonic reactors in the dc link circuit as an integral part of the VSD.

Unless otherwise stipulated on the submitted application VSD data sheet, the scope of supply envisaged is for the AC/DC--DC/AC converters only.

39.18.1.6 System Protection

The converter panel shall be complete with all required motor and converter protection devices of the electronic type, incoming mains power disconnect switch, multipurpose metering instrument in panel front for indication of voltage, current, power, speed; torque, panel temperature; transmitters for remote indication of power, speed; torque temperature; set-point control and shall provide a standard interface for remote control and monitoring.

The VSD system is to provide protection to motors from:

- Over current;
- Over voltage;
- Under voltage;
- Overload; and
- Over heating;

and to include facilities for

- Current limiting setting;
- Auto restart following trip or power supply recovery;
- Soft stall function; and
- Reactivation function following a momentary power interrupt.

39.18.1.7 VSD Overload Protection

The VSD is to be protected on the power outlet against short circuits or earth faults on the motor terminals. The three phases of the supply are to be continuously monitored and the system to shut down on a missing phase or overload.

The supplier shall include a DC choke and/or line reactor to limit the Voltage total harmonic distortion to the limits given in the IEEE-519. The limit for a general system is stipulated at 5%.

Specific calculated proof of meeting the required 5% voltage total harmonic distortion (VTHD) limits shall be provided.

The following protection must be included as a minimum:

a) DC Link Over Voltage;
b) DC Link Under Voltage;
c) Output Short Circuit;
d) Output Earth Fault;
e) Output Over Current;
f) Motor Overload; and
g) Inverter Over Temperature.

The suppler shall provide storage of all faults on the VSD, as well as last fault memory in the event of power failure is required.

39.18.1.8 Motor overload Protection

The VSD is to provide electronic thermal overload protection of the motor at all operating speeds. This protection is to allow for the cooling conditions experienced with the speed control. The VSD is to allow for a built-in motor thermistor should the motor size be 22 kW or more.

The VSD is to incorporate line reactors as necessary to achieve a power factor of the driven motor of not less than 0.9 at any given speed.

39.18.1.9 Inverter Waveform

The VSD is to have manufacturers installed protection devices on the outgoing supply to the motor to suppress the effects of the inverter wave form.

The VSD is to be of the type utilising digital PWM technology which will enable the full output voltage to be reached without waveform distortion. Derating of the specified motor kW is not permitted.

The VSD is to provide slip regulation by means of vector control of the output voltage and frequency to maintain a constant motor speed.

39.18.1.10 Motor Noise

Electromagnetic noise generated by the VSD and motor is not to exceed a 10% increase over that of a standard motor on a commercial power supply when operating over the specified duty range.

The additional vibration generated by the motor when operated at reduced speed is to be attenuated by stiffness of base and selection of anti-vibration mountings. The resultant vibration transmitted to building structure is be no more than that of a standard motor on a commercial power supply.

39.18.1.11 Radio Frequency / Interference / Radiated and Conducted Interference

The VSD is to have manufacturers built in filters to suppress RFI, radiated and conducted interference.

The VSD is to comply with EMC/EMI standards for immunity IEC 802-805.

The VSD is to be contained in a metal enclosure to suppress radiated RFI. The earthing of this enclosure is to be taken direct to earth.

39.18.1.12 Computer Interface

The VSD is normally connected to a local standalone controller and with facilities to interface with a Network or Central Control Panel. Interface facilities are required to allow operation and make data settings from a host computer.

Monitoring of the speed controller status is to be provided giving:

- Output frequency;
- Output current;
- Output voltage; and
- Trip conditions.

39.19 MEDIUM VOLTAGE VARIABLE SPEED DRIVES (VSD)

39.19.1 Scope

This specification includes the manufacturing, test, supply, delivery, transport, handling, protection, storage, installation, successful commissioning and upholding during the Defects Liability Period.

The Drive shall be factory pre-wired, assembled and tested as a complete package by the Drive supplier. Customer specific drive, motor, and application data shall be pre-loaded into the operator interface and tested prior to shipment.

The applicable scope of the works covered by this section shall be defined in the Variations and Additions to the Standard and Particular Specifications and relevant Tender drawings.

The Drive supplier shall complete and submit Attached data sheets with the proposal, The OEM of the drive shall demonstrate at least 10 years' experience in manufacturing of medium voltage drives of the voltage and size required for the specific application.

39.19.2 Submittals

VSD Manufacturer shall submit drawings and data as specified below as part of bid information:

a) Basic description of all major components and basic control and protection features of VFD;

b) Outline drawings showing outside dimensions, weights for VSD System (transformer + VFD) and estimated heat loss for VFD system (Transformer + VFD);

c) Single-line diagrams showing all major components within the system;

d) Recommended spare parts list; and

e) Terms of standard warranty.

Following drawings and data will be submitted for engineering review per agreed project schedule:

a) Control schematic for the system;

b) Control schematic for the VSD Plant; and

c) Operation and Programming Manual(s).

Test reports will be supplied as part of factory testing for inspection and performance.

39.19.3 Warranty

Seller shall warrant the Plant for a minimum period of 12 months from date of startup. Warranty shall cover both parts and labour for required repairs.

Seller must state clearly the details of warranty offered with his Plant.

39.19.4 General

MV VSD's shall be capable of controlling and correctly protecting the motor throughout the required frequency range.

MV VSD's should include protection features to ensure that the motor may not operate in an overload condition which may cause damage to the connected motor.

MV VSD's shall be selected based on the full load operating current of the motor. No under sizing of the VSD is permitted, nor should oversizing be necessary.

MV VSD shall be capable of operating with High Efficiency motors of classes IE2, IE3 and IE4.

39.19.5 Construction Requirements

The drive shall be modular design to provide for ease and speed of maintenance. All panels should be free-standing, floor-mounting, and arranged for front operation and front access to all Plant. The design shall be considered as the following six modules:

a) Incoming Medium Voltage Isolation Module;

b) Phase Controlled Bridge Rectifier Module;

c) DC Link Power Circuit Module;

d) Current Source GTO Controlled Bridge Inverter Module;

e) Motor Filter Module; and

f) Low Voltage Digital Control Section.

39.19.6 Mechanical

The VSD assembly and its enclosure protection class (IEC IP 21) should allow indoor installation within unclassified area. Door vents shall have louvered panel assemblies that can be removed from the front to allow cleaning and/or replacement of air filters.

Filter vents shall have metal covers / barriers on inner side of door panel for line-of-sight protection to limit exposure or access to installed power components.

All doors on the power electronic solid-state device sections shall be kirk-key interlocked with the door on the control cabinet, thus preventing opening of any door by bypassing electrical interlocking signals.

All control boards used within VSD shall be coated such that there can be no damage from moisture or dust in the ambient environment.

An arc detection monitor shall be provided for each power module to detect any arcing in the power section of the VSD.

The power electronic solid-state device power section shall contain individual draw-out power cells with stab connections to AC power bus bars for each phase. A cart designed for removing and inserting power electronic solid-state device power cells shall be supplied.

Air filters shall be of reusable / washable type that can be easily cleaned. Air exhaust from cooling fans will be at the top of the enclosure.

Fan motors shall be protected by an input circuit breaker. Fan power will be supplied from a separate control transformer and is not tapped from the main drive isolation transformer.

The maximum noise level of the unit shall not exceed 80 dBA at a distance of (1 meter) from the unit and at a height of (1.5 meters) from the floor.

All enclosures will have manufacturer’s standard finish unless otherwise specified by the purchaser.

Enclosures shall be designed to accommodate power cable entry from either top or bottom.

39.19.7 Enclosure Auxiliary Components

Space heater elements shall be supplied to avoid any condensation inside the enclosure.

The space heater circuit shall turn on when the drive is not operating. Thermostat control cannot determine the dew point.

A circuit breaker for the space heater circuit shall be provided for overload protection and as a disconnecting means.

Enclosures shall be equipped with LED lighting, or as specified by the purchaser.

39.19.8 Enclosure Nameplates

Engraved, laminated plastic nameplates with characters 1/2 inch (12.7 mm) high, or larger, shall be provided for each VSD to identify the load it serves.

Nameplates shall have black letters on a white background.

Meters, relays, switches, and other devices within the VSD shall be permanently identified using the same name as those appearing on the schematic diagrams.

39.19.9 ELECTRICAL

39.19.9.1 Power Requirements

The VSD shall be capable of providing rated output for continuous input voltage deviations of ±10% from the nominal, and also deviate -10% up to -20% from the nominal with output power derating.

Output power transistors shall default to open without additional circuitry in the event of a motor short circuit.

The VSD shall be able to ride through voltage dips down to 80% of its nominal voltage rating, such as those experienced during motor starting.

The VSD shall have ride-through capability upon loss of incoming power for 2 seconds.

The VSD one-minute overload current rating shall be 115% of rated current for variable torque applications.

The power transistors power devices will be switched based on technique searches for best switching frequency and switching angels for power transistors that optimize the harmonics in the output voltage / current waveform, and possibility the output waveform almost equivalent to the fundamental sinusoidal wave.

Output filters, as required, shall be integral to the drive cabinet.

39.19.9.2 Input Phase Shifting Transformer

The VSD supplier shall use a dry type phase shifting transformer whose primary voltage, made in star configuration, shall be as specified by the purchaser.

The windings shall be Aluminum or Copper, as specified by the Purchaser.

The phase shifting transformer shall have phase shifted secondary windings made in delta to feed 3 phase power to each power cell.

Any secondary windings shall be connected to each power cell and should be insulated from each other.

The system shall be supplied with dry type phase shifting transformer mounted with the VSD in order to meet the necessary insulation and current harmonics cancelation.

The transformer shall have an electrostatic shield for protection from voltage transients.

The phase shifting transformer shall has an auxiliary winding responsible for the pre-charge system.

Pre-charging of the DC link capacitors shall be accomplished by use of low voltage internal of the transformer the auxiliary winding and shall be interlocked with the main input power such that the VSD cannot be energized until DC bus is charged to safe pre-set voltage level.

39.19.10 Environmental Condition to Service

The 3,3 kV or 6,6 kV output voltage switchgear and motor starter panels will be installed indoors on an industrial plant.

Metal or plastic barriers shall be provided between each vertical section and between the low voltage compartment and Medium voltage compartments. Personnel shall have access to the low voltage compartment, with the Drive energized, without being exposed to any medium voltage.

The Drive shall operate in an ambient temperature range of -5°C to 55°C with a relative humidity of up to 80% (non-condensing), unless specified otherwise. The Drive's will be installed in an air-conditioning facility or normal ventilation if water cooled units is offered. The drive must be suitable for operation at 1400 m above sea level.

39.19.11 Drive Performance Requirements

The Drive shall produce a variable voltage and variable frequency output to provide continuous operation over the application speed range. The Drive shall be capable of operating with the output short circuited at full current or with the output open circuited at rated voltage.

The Drive shall be capable of operating one of the following motors of equivalent power and speed rating over the speed range 45-110%:

- Standard AC squirrel cage induction motor;
- Standard AC synchronous motor (DC brush type or AC brushless type); and
- Standard AC wound rotor induction motor.

Motors shall not require de-rating or upgraded turn-to-turn winding insulation and shall not require service factor upgrading.

The drive system shall provide controlled speed over the range specified. Speed accuracy within this range, shall be within 0.1%, of the 100% speed, without encoder or pulse tachometer feedback (0.01% with encoder or pulse tachometer feedback).

The Drive shall have a "normal duty" rating of 100% continuous current with a short-time duty rating of 110% overload for one minute, once every 10 minutes (suitable for variable torque loads). A "heavy duty" rating shall be 100% continuous current with a short time duty rating of 150% overload for one minute, once every 10 minutes (suitable for constant torque loads).

The Drive shall be capable of 100% breakaway torque without tachometer feedback. Breakaway torque with tachometer feedback shall be 150% (The breakaway torque shall not exceed 80% of the motor break down torque.)

For high inertia loads, a preference shall be given to Drives capable of regenerative motor braking. For overhauling loads, regenerative braking capability shall be mandatory.

The drive shall have a minimum efficiency of 96% at 100% speed and load. The efficiency shall include the drive, input transformer or line reactor, harmonic filter, power factor (pf) correction unit

and output filter (whichever is applicable). Control power supplies, control circuits, cooling fans or pumps, shall be included in all loss calculations.

The VSD shall meet local requirements for telephone interference restrictions.

Maximum audible noise from the Drive or associated Drive system shall comply with OSHA standard 3074, Hearing Conservation, which limits noise level to 85 dB(A), at a distance of one meter from the front of the Plant (with doors closed at any speed or load condition). If Drive system's audible noise is in excess of this limit, sufficient noise abatement treatment to reduce the sound pressure level below 85 dB(A) must be included in the offer.

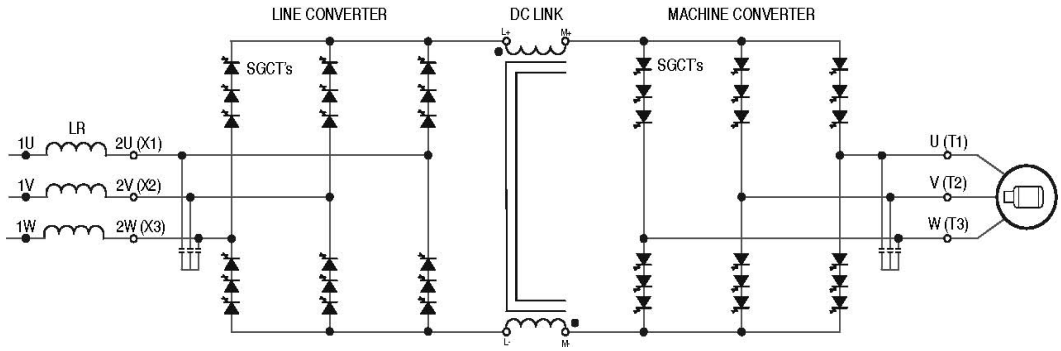
The drive shall be capable of maintaining a minimum true power factor, (Displacement PF. x Distortion PF.) of 0.97 from 40-100% of the speed. If the true power factor that can be met and additional power factor correction unit shall be Included in the proposal.

The drive system shall be capable of operating with a voltage sag of 30% on the input power.

The drive shall be capable of restarting and taking control of a motor attached to a spinning load in the forward or reverse direction.

The drive shall have a minimum life expectancy of 15 years.

The basic power diagram of the direct-to-drive arrange which is preferred is shown below in Figure.1.



The basic power diagram of the transformer front end arrangement (alternative tender) is shown below in Figure 2.

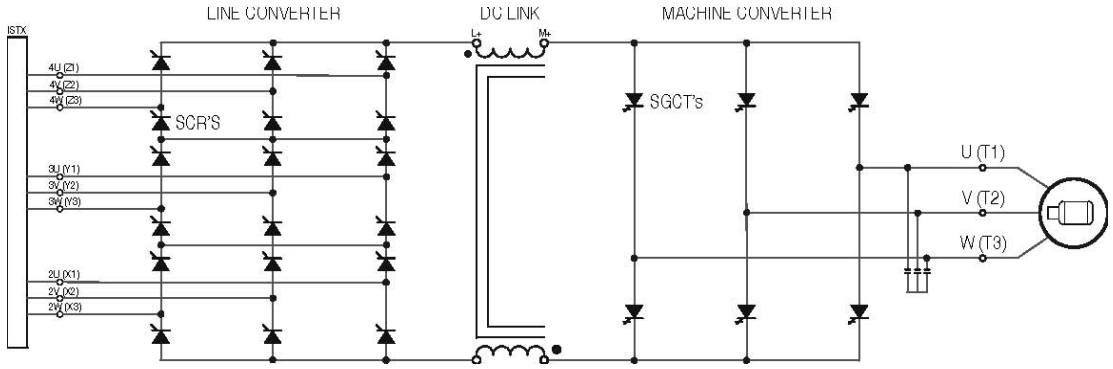


Figure 1 and 2 are merely basic diagrams of the power arrangement of the VSD's and do not depict any detail auxiliary Plant or control Plant.

The VSD Plant shall consist of a filtered active front end and rectifiers which supplies DC power via a current limiting DC link inductor to the inverter section of the VSD. The Plant shall utilise a Pulse Width Modulated (PWM) – Current Source Inverter (CSI) for the machine side converter. The topology shall offer a simple, reliable, cost-effective power structure with the number of inverter components kept to a minimum.

39.19.12 Insulation

All the Medium Voltage current-carrying parts shall be fully insulated or otherwise screened off and spaced in such a way that the basic insulation level shall be maintained under all working conditions.

39.19.13 Drive Protection

The Drive shall have the following minimum protection features:

a) Under voltage (adjustable);
b) Over voltage (adjustable);
c) Instantaneous over current (adjustable);
d) Ground fault (adjustable);
e) Overload (adjustable);
f) Gate driver power supply under voltage;
g) Control power over / under voltage and signals;
h) Drive over temperature protection;
i) Short circuit protection (instantaneous over current);
j) Motor Overload (delayed over current);
k) Motor over speed (adjustable);
l) Phase Loss Detection;
m) Phase Imbalance Detection; and
n) VSD over temperature.

39.19.14 Motor Protection

a) Electronic motor overload protection shall be supplied as standard.
b) An RTD relay for sensing actual motor temperature and drive shutdown shall be supplied.
c) A motor stall protective function must be supplied. The amount of time the drive will be allowed to run at current limit under minimum speed shall be adjustable.
d) A multi-functional motor protection relay (MPR) shall be supplied when a bypass starter is requested.
e) If specified in Variations to particular specs, motor space heater control shall be provided.

Busbars shall be manufactured from hard drawn high conductivity copper of ample and suitable cross-sectional area for the specified fault currents. The busbars shall be fully insulated and marked with their phase colours.

39.19.15 Isolating Contacts

Isolating contacts shall be provided for circuit breakers / contactors. They shall be of the self-aligning type and must not transfer mechanical stresses. All accesses to the isolating contacts shall be equipped with mechanical shutters being operated by plugging-in or withdrawal of the circuit breaker / contactor. Facilities shall be provided to lock the shutters in the closed position.

Shutters for busbar contacts shall be painted red while those for cable contacts shall be painted yellow. Shutters for double busbars shall be marked according to the busbar position.

39.19.16 Operator Interface and Communication

The Drive shall have a user-friendly Man machine interface terminal with the following minimum features:

a) Large LCD display that are easy to read and provide ‘at a glance’ indication of drive operating status;

b) User configurable bar type LCD metering for motor speed, load, torque, current and voltage;

c) Motor and Drive run time indications (Motor Run time reset able by highest level password only);

d) Extensive diagnostic functions that provide separate fault and warning queues in non-volatile memory that retain information under all conditions;

e) On-line help that provides enhanced fault text messages;

f) Trend buffers for at least 8 variables that allow one-shot or multi-shot trending;

g) Multi-level password access to ensure that only qualified personnel have access to critical parameters but still allow easy access to other levels of personnel;

h) Extended use of plain language messages to eliminate need to look up error codes or decipher the meaning of error messages; and

i) Start-up wizard, including auto tuning, that is interactive and user-friendly.

39.19.17 Communications

The drive shall be provided with digital communication capability to allow direct control and status communication with a PLC, SCADA or other control system. The communication protocol shall be that specified in the Variations to Particular specifications or compatible with the other networks used in the projects. Communication modules for Remote I/O, will be suitable for DIN rail mounting or communication board mounting.

39.19.18 Inputs and Outputs

Isolated analog signal interfaces (maximum of four (4)) shall be configurable for:

a) Speed reference input (4-20 mA input signal);

b) Speed output (4-20 mA output signal);

c) Current output (4-20 mA output signal);

d) Load (kW) output (4-20 mA output signal); and

e) Torque output (4-20 mA output signal).

Windows based application software shall be provided to monitor and edit drive parameters, upload and save parameters to a file, download parameters to the drive, print parameters, and view and clear faults / alarms in the drive.

The Drive shall be controlled locally via start/stop push buttons, emergency stop push button, local / remote selector switch, and speed reference potentiometer.

39.19.19 Cooling Systems

The drive system shall be air-cooled unless otherwise specified in the attached data sheet.

Air-cooled drives shall be provided with a mixed flow cooling fan, mounted integral to the drive enclosure. The drive shall include air-flow pressure switches and temperature detectors to monitor proper operation of the air-cooling system. If a fan fails, the system must generate alarm indication of the fan failure. Vane type air-flow switches are not acceptable.

If specified on the attached data sheet, provision shall be made for ducting VSD exhaust air outside the control room.

39.19.20 Circuit Breaker / Contactor

The circuit breaker / contactor shall be of the metal clad, vacuum interrupter, three poles and trolley mounted type.

The raising gear for the circuit breaker / contactor coupling and uncoupling shall be robust and very reliable.

Vacuum-circuit-breakers shall be triple pole, latching and of a trip-free design. Either draw-out units or permanently mounted Plant may be required. Circuit breakers shall be hand-closed or be fitted with a closing solenoid. Solenoid closing circuit breakers shall be provided with a re-closing preventive interlock.

39.19.21 Electrical Interlocking

Electrical interlocking where necessary shall be specified in the Variations and Additions to Standard and Particular Specifications.

39.19.22 Treatment and Painting of Metal Panels

All metal parts shall be treated before painting in accordance with the requirements of standard corrosion protection specifications and the appropriate coating system shall be selected for the specific application.

39.19.23 Monitoring, Control and Wiring

Voltage free contacts shall be provided for circuit breaker spring charged indication and position indications.

Control circuits shall be wired with 600/1000 V grade PVC insulated cables complying with SANS 1507. These cables shall have at least 7 strands with a total cross-section of not less than 2,5 mm².

Inter panel connection PVC covered conductors shall be protected by means of non-conducting grommets at panel through holes to prevent damage to conductor outer sheath.

The internal wiring of the boards shall consist of coloured PVC-insulated conductors which shall be neatly installed horizontally and vertically in PVC trunking. Numbered ferrules of an approved type (clip on type not acceptable), shall be provided on each end of each wire, to facilitate the tracing of circuits.

Control circuits shall be colour coded as follows:

A.C. Live	Red or (Brown)
A.C. Neutral	Black or (Blue)
110V D.C. Positive	Grey
110V D.C. Negative	Grey
24V D.C. +ve	Brown
24V D.C. –ve	Orange
4-20mA	Purple
All other voltages	Violet
Status signals	Pink
Earth	Green and yellow

39.19.24 Earthing Facilities and Earth Bar

The Drive shall have integral facilities to earth cable circuits via the circuit breaker and the necessary auxiliary gear shall be provided to earth the busbars. The earthing of busbars shall preferably only be possible on the incoming supply panels.

The earth bars shall not be rated at more than 80 A/mm² based on the specified earth fault rating. Across the bolt holes the current density shall not exceed 100 A/mm².

Earth bars, earth blocks, cable boxes and glands shall be bonded with the panels by using brass bolts and nuts unless otherwise specified. Not more than two earth conductors will be permitted on a single connection point.

The earth bar shall be in an acceptable position to allow for earthing of cables and shall have sufficient connection points to take all earth wires. Connection points shall be equipped with cadmium plated bolts, nuts, washers and spring washers.

All instruments, meters, relays etc., mounted on hinged doors as well as the doors themselves shall be earthed.

39.19.25 Cable End Box

Cable boxes shall be suitable to accommodate the cable or cables for each circuit as specified. This applies not only to the number of cores, size and conductor material, but also to the type and construction of the cables.

Cable boxes shall be complete with the necessary clamps, tapes, glands, compound, terminating and other accessories. The type of preferred compound will be stated in the Variations and Additions to Standard and Particular Specifications. If heat shrink cable ends are specified then the end boxes shall be provided complete with the necessary wooden cable clamps and all accessories.

Mechanical cable glands for control and auxiliary cables shall be suitable for PVC/SWA/PVC type cables. The armouring shall be clamped firmly to ensure a reasonably good electrical connection and to prevent the cables from being pulled out easily. Each gland shall be complete with a neoprene shroud and one locknut.

39.19.26 Labels and Inscriptions

The standard labels on Plant regarding the manufacturer, type, class, rating etc., shall be accepted unchanged.

Engraved laminated plastic labels shall however be provided to indicate the main circuits as well as the functions of relays, fuses, links, lights and selector and control switches and shall correspond with the numbering system on the circuit diagrams. These labels shall be fixed with screws, bolts or rivets.

The proposed wording of labels as well as those for flagging or alarm relays in alarm panels shall be in English and submitted to the Engineer for approval.

Framed glass covered general arrangement drawings and circuit diagrams shall be provided in substations and shall be wall mounted and prominently displayed.

39.19.27 Factory Testing

The request for witnessed testing is based on the understanding that the manufacturer conducts tests on the boards as routine tests and the costs therefore are included in the price makeup of the Plant.

Suppliers who cannot produce satisfactory test evidence that their Plant has passed short-circuit tests at the specified fault levels, must include in their tender for those tests to be carried out at the SABS testing laboratories. These tests shall be witnessed by the Engineer.

The supplier shall inform the Engineer at least 3 working days in advance when the Plant is ready for routine testing.

The following routine tests shall be witnessed:

a) Checking and testing of all current and auxiliary transformers;
b) Checking and testing of instruments and meters;
c) Checking of all relay settings;
d) Testing the overloads and functioning of the miniature circuit breakers;
e) Bell testing of the panel wiring on uniformity and consistency. Checking of the wire markings;
f) Functional testing of the Plant and the mechanical interlocks;
g) Checking the auxiliary transformers on ratio, output, heat losses and noise level; and
h) Pressure testing of the boards by applying 2 x Rated AC Voltage 50 Hz holding this voltage for 60s phase to phase, phase and neutral and phase to earth.

39.19.28 Maintenance Tools Plant

a) Spare fuses and lamps:
   i) One spare fuse shall be provided for each fuse used on the switch gear;
   ii) Two spare lamps shall be provided for each lamp used on the switch gear; and
   iii) The spare lamps and fuses shall not be used by the Contractor.
b) Tools, Toolboxes and brackets.

At least two spring charging handles, operating handles and door keys as well as one remote operating chicken switch shall be provided for each substation.

Wall mounted brackets shall be provided for carrying the manual operating handles and test jumpers.

If special tools are required, a complete set of finished case-hardened spanners and special wrenches to fit every nut and bolt on the Plant supplied shall be provided under this Contract. Any special tools or keys that may be required for effecting adjustments of parts as well as all standard earthing and test Plant, shall also be provided.

These tools shall be accommodated in a suitable, neat, and properly designed; wall constructed steel Plant cabinet with tool positions marked. The cabinet shall be capable of being locked by means of a padlock.

A fully detailed list of tools shall be supplied before delivery.

The tools shall not be used for the erection of the Contract Works.

All toolboxes and testing Plant brackets shall be properly fitted against substation walls in suitable positions.

39.19.29 Test Plant

The following is understood under test Plant and shall be supplied as part of the Contract for every switchboard:

a) Plug-in contacts to establish a connection with the 11 kV isolating contacts on the switch gear for the purpose of pressure and injection testing as well as cable fault finding; and
b) An extension cable with plugging contacts and sockets to establish a connection between a circuit breaker and the secondary circuits on the fixed part of the switch gear for the checking of the secondary circuits.

39.19.30 Handbooks

At least 2 months prior to the commissioning of any Plant, the Contractor shall submit to the Engineer four (4) sets of handbooks giving full particulars of all the Drive components. Final drawings shall be available in DWG format at no charge. Under full particulars the following shall be understood:

a) Drive technical descriptions and specifications;
b) Erection and commissioning instructions;

c) Operating instructions;

d) Descriptions of the operation, setting, adjusting and maintenance of the Drive;

e) A parts list with illustrations for the correct identification and ordering of parts; and

f) Certified drawings, instruction and maintenance manuals Final drawings shall be available in DWG format at no charge.

A draft handbook shall be submitted to the Engineer in advance for approval. Approval drawings and handbooks can be sent electronically via the Internet, as an alternative to sending them by mail in PDF format.

39.19.31 Commissioning and Training

a) Start-up will be performed at the user's site.

b) The supplier shall arrange a pre-installation meeting with the user to review:
   - The start-up plan;
   - The start-up schedule; and
   - The drive's installation requirements.

c) Inspect the drive's mechanical and electrical devices enclosed.

d) Verify and adjust mechanical interlocks for permanent location.

e) Re-verify control wiring from any external control devices.

f) Set up all drive internal power supplies and power transistors control circuits.

g) Verification of proper phasing from isolation transformer to drive.

h) Perform Megger test.

i) Apply medium voltage to the drive and perform operational checks:
   - Bump motor and tune drive to the system attributes (if the load is unable to handle any movement in the reverse direction, the load should be uncoupled prior to bumping the motor for directional testing); and
   - Run the drive motor system throughout the operational range to verify proper performance.

39.19.32 Factory Training

The Supplier shall offer Medium Voltage Drives Training at the Supplier’s factory. The training sessions shall be designed for maintenance and operations personnel and should include troubleshooting and maintenance of the Medium Voltage drives installed. Traveling, Training, accommodation one day prior and two days after the training, three meals/day, Manuals and documentation will be provided per participants. Factory training shall be done at least two weeks prior to commissioning.

The training shall cover the following minimum topics:

a) Basic motor theory;

b) Theory of operation;

c) Drive hardware;

d) Drive firmware;

e) Cooling system operation;
f) Operator interface;
g) Board replacement procedures;
h) Power device replacement procedures;
i) Fault analysis and troubleshooting; and
j) Preventative maintenance procedures.

Hands-on labs shall be included in the training. Demos shall be provided to allow the students to apply the lecture material to a fully functional demo unit.

39.19.33 On-Site Training

The Supplier shall also provide a qualified instructor to provide user's personnel with training that is specific to the system installed at the facility. The Supplier shall outline the training session duration and content. Training, Manuals and documentation shall be provided for each participant (a minimum of three (3) and a maximum of eight (8) participants must be allowed for).

The training shall cover the same topics as the factory training.

39.20 LOW VOLTAGE ELECTRONIC SOFT STARTERS

Not Used.

39.21 MEDIUM VOLTAGE SOFT STARTERS

Not Used.

39.22 FIRE DETECTION AND PROTECTION SYSTEM

39.22.1 Scope and Standards

The scope of this Clause includes the design, manufacture, testing at Works, supply, installation and commissioning of fire detection and protection systems at pumping stations. The design shall also take in account the impact and control of all other systems that influence the internal fire risks.

This should be read in conjunction with Section 38.

39.22.1.1 Areas to be Protected

The following table describes the rooms to be protected (approximate measurements only; actual measurements to be verified on site prior to putting work in hand):

DETECTION ZONE	AREA NAME	AREA M²	VOLUME M³
A	**High Lift Pumping Station**		
1.	Battery Room	12m²	41m³

DETECTION ZONE	AREA NAME	AREA M²	VOLUME M³
2.	UPS Room	12m²	40m³
3.	MV	96m²	327m³
4.	LV & MCC	30m²	102m³
5.	VSD	212m²	721m³
B	**Low Lift Pumping Station**		
6.	VSD	142m²	485m³
7.	MV	120m²	410m³
8.	LV & MCC	40m²	136m³

Note: It remains the responsibility of the tenderer to calculate the exact room volumes to determine gas quantities.

39.22.1.2 Standards

SANS 10139 : Code of Practice “The prevention, automatic detection and extinguishing of fires in buildings”

SANS 019 : Code of Practice “Portable metal containers for compressed gasses:
Basic Design Criteria, Use and Maintenance”

SANS 4706 : Refillable Welded Steel Gas Cylinders

SANS 4705 : Refillable Seamless Steel Gas Cylinders

SANS 14520 : Part 1 Code of Practice
Gaseous fire-extinguishing systems-Physical properties and system design

SANS 14520 : Part 14 IG-55 extinguishant
Specific to gaseous suppression agent

SANS 369 : Electrical actuation of gaseous total flooding extinguishing

SANS EN54 : Components of Automatic Fire Detection Systems

SANS 50054 : Fire Detection and Fire Alarm Systems

SANS 10142 : Wiring of Premises Part; Low voltage installation

The Contractor shall comply with all requirements of the Occupational Health and Safety Act (Act 85 of 1993) and Construction Regulations and all subsequent revisions thereof. Further, the Contractor undertakes to employ only people who have been duly authorised in terms thereof and who have received sufficient health and safety training to ensure that they can comply therewith.

39.22.2 General

The work to be carried out consists of the detailed design, engineering, manufacturing, supply, delivery, offloading, erection, testing and commissioning into service, guarantee and maintenance of an automatic fire detection and protection system appropriate for the industrial application in pumping stations. The internal fire risk is predominantly electrical fires.

The engineering, quality control and inspections, Plant selection, preparation of shop drawings, testing, commissioning and preparation of operating and maintenance manuals, are to be executed in a systematic manner.

Design, selection, construction details and installation arrangements for Plant and/or distribution systems which are available from either the manufacturer / supplier in their officially published literature / documentation, design / application manuals, or other authoritative sources such as SANS, BS, NFPA, etc. shall be used as the basis for shop drawings. The specific source shall be identified at submission stage.

39.22.2.1 Design Calculation

The Contractor shall submit for perusal by the Engineer copies of his detailed design calculations within the time period specified in the specification. These shall include at least the following:

- System sizing calculations. Design concentration shall be clearly indicated for each and every zone or space, and whether such spaces are normally occupied or normally unoccupied;
- Distribution system detail design. All discharge pressures, both upstream and downstream of the main orifice shall be clearly indicated, together with proposed nozzle and pipe sizes, specifications, and allowable working pressures; and
- Final discharge quantities for every protected space, design concentration, 95% discharge time.

39.22.2.2 Plant Selection Submission

The Contractor shall select Plant components which complies with these Employer's requirements. These selections shall be submitted to the Engineer for approval.

No Plant shall be installed until the Plant selection submission has been approved by the Engineer if the selected plant deviates from the design concept and/or deviates from the accepted Plant offered.

39.22.2.3 Compatibility

All the components of a fire detection and protection system shall be mutually compatible.

Compliance of an individual component with any standard or approval does not necessarily guarantee that it will work satisfactorily in conjunction with another component that complies with another standard.

The Contractor shall consider the subjects below, and the data provided with each item shall provide the information necessary for the consideration of its compatibility with other items. All specifications and details are to be forwarded to the Engineer for approval.

In relation to a given control and indicating panel, such consideration shall include at least the following:

a) For all devices:
   - The requirements of the system in order to satisfy electrical safety requirements;
   - Any provision for earthing;

- The earth insulation resistance;
- The method of adjustment where adjustment is required to ensure compatibility;
- Any preferred method(s) for monitoring line continuity;
- Whether the current taken or delivered has an appreciable reactive component;
- The characteristics of any signals that pass between components;
- The ability of the control and indicating Plant to operate in conjunction with the number of devices to which it will be connected;
- Any software provided for programming the system or its components, and the compatibility of other components with the software; and
- Any limitations on the numbers, types, sizes or other parameters (such as impedance) of wires that can be connected.

b) For fire detectors:

- The form of output;
- The operating voltage, including tolerances;
- The quiescent current;
- The alarm current or maximum permissible alarm current rating;
- The method of resetting the device after an alarm;
- The states of the detector that indicate normal conditions, fault conditions and fire conditions;
- Any requirements for indications of operation to be provided in the vicinity of a detector, together with any resultant changes in system conditions, e.g. reliability or power consumption; and
- The number of conductors required.

c) For alarm devices:

- Whether polarized connection is required;
- Whether precautions might be required in order to suppress any interference generated by the device;
- What methods for monitoring the interconnections can be used;
- Whether the power supply arrangements can provide sufficient power; and
- Whether a high starting current is required.

d) For manual call points:

- Whether they are of open or closed circuit operation;
- Whether they are of polarized operation;
- The method of discrimination between alarm and fault conditions; and
- The method of resetting the device after an alarm.

e) For power supplies:

- The correct voltage for the type of battery used (i.e. lead-acid or alkaline types);
- The correct charging characteristics for the type of battery (i.e. constant current or constant voltage);
- The relationship between polarity and earth, or whether the potential is earth-free;

- The current rating in relation to calculated maximum demand;
- The permissible limits of ripple;
- The degree of stabilization;
- The formula for power capacity for the system, including the storage capacity of the standby supplies and the required standby duration;
- The permissible range for the supply voltage; and
- Whether the standby power supplies are able to provide the necessary current for the specified duration.

f) For automatic fire protection Plant:

- Whether the energy required by the automatic fire protection Plant is available from the control and indicating Plant or whether additional power supplies will be required;
- Whether the voltage(s) required by the automatic fire protection Plant are compatible with those available from the control and indicating Plant;
- Whether the Plant is compatible with proposed monitoring facilities;
- Whether the Plant requires positive or negative switched input; and
- Whether the Plant is normally energized or normally de-energized;
- The functions provided;
- The signal conditions for each function; and
- The terminal connections.

Plant for transmitting fire alarms and fault warnings to remote manned centres should be compatible with the Plant at the remote manned Operations and Control Centre.

39.22.2.4 Identification

A label shall be provided under each device, detector, relay, controller and panel identifying the Plant controlled and/or performance indication by such items.

The labels shall consist of a non-corroding material with a non-glossy appearance, engraved with black, lettering on a white background.

In additional to the warning and information labels that shall be provided in accordance with SANS 10142, a label shall be provided on any isolating protective device that affects the fire alarm system and should read as follows:

"Warning: this switch also controls the supply to the fire alarm system"

39.22.2.5 Interfacing with Other Systems

The system must be capable of interfacing with other systems via Input / Output units, relays and similar Plant. All relays and Plant beyond the Input / Output units will be provided by others. The systems to be interfaced include:

SYSTEM	ACTION
HSSD Systems	Interface and monitoring of all High Sensitivity Smoke Detectors (HSSD) with Gas Control Panels.
Any Fresh Air Systems	To shut down fresh air supplies.
Fire Dampers	Closing of any fire dampers.
PLC Platform	All specified fire signals from HSSD detectors as well as Gas Release Control Panels to be interfaced with the client's PLC Platform.
Pilot Cylinder Pressure Gauge	Monitoring of the pressure on all pilot cylinders for a drop in pressure.
Gas Suppression System	All connections to actuators inside gas cylinder room to release gas on confirmation of a double knock fire signal
Addressable Control Panel	Interfacing to Gas Control Panel and High Sensitivity Smoke Detectors as well as all optical devices.
Main Building Addressable System	Activate sounders to warn occupants should a signal be send by the gas control panel to the Main Addressable Panel of the building.
Gas Release Control Panels as well as HSSD	Monitoring of specified signals • Fault • Fire • Auto / Manual Switching • Gas Discharge • Pressure drop – Pilot Cylinder • Alert

39.22.3 Gas Suppression Systems

39.22.3.1 Extinguishant

The extinguishant to be used for this project shall have zero Ozone Depleting Potential in manufacture or composition; i.e. IG-55 (Pyroshield) complying with the following properties: SANS 14520 – Part 14: IG 55.

DESCRIPTION	ARGON	NITROGEN	CARBON DIOXIDE
Purity	> 99.9%	< 99.9%	<99.5%
Moisture Content	$< 4 \times 10^{-6}$	$< 5 \times 10^{-6}$	$< 10 \times 10^{-6}$

PROPERTY	UNITS	VALUE
Molecular Mass	-	34
Boiling point at 1,013 bar (absolute)	°C	-196
Freezing point	°C	-78.5
Critical temperature	°C	–
Critical pressure	bar abs	–
Critical volume	cm^3/mol	–
Critical density	Kg/m°	–
Vapour pressure 20°C	bar abs	152
Liquid density 20°C	kg/m^3	–
Saturated vapour density 20°C	kg/m^3	–
Specific volume of superheated vapour at 1.013 bar and 20°C	m^3/kg	0.706
Components	N_2 – 52% by volume Ar – 40% by volume CO_2 - 8% by volume	

The design concentration for this application shall be 39.9%.or as otherwise approved.

39.22.3.2 Buildings

The project involves for the detailed design, manufacturing, supply, delivery, offloading, erection of new fire detection and gaseous suppression systems at the Low Lift and High Lift Pumping Stations of the Mokolo Crocodile Water Augmentation Project in Lephalale / Thabazimbi in Limpopo Province.

The buildings are made up of the following occupancy classification in terms of Regulation A20 of the *National Building Regulations and Building Standards Act (Act 103 of 1977)*:

CLASS OF OCCUPANCY	OCCUPANCY
D4	Plant room Occupancy comprising usually unattended mechanical or electrical services necessary for the running of a building.
G1	Offices Occupancy comprising offices, banks, consulting rooms and other similar usage

(a) System Description

The various 200 Bar 80 Litre IG-55 Pyroshield clean agent Automatic Fire Extinguishing Systems shall be an engineered system utilising a fixed nozzle agent distribution network. It shall be installed in accordance with the SANS 14520-14, SANS 369 and SANS 10139 Codes of Practice.

The system shall be actuated by detection and control Plant for automatic system operation along with providing local and remote manual operation as required.

The gas system shall consist of a total storage bank and be capable of totally flooding the protected areas to a design concentration applicable to the gas offered at an ambient temperature of 21°C. Discharge times will be those as specified in the SANS ISO 14520 – Part 1 and Part 14 Code of Practice.

In determining the quantity of gas required to achieve the necessary concentration for a period of not less than 10 minutes, the Contractor shall allow for and provide additional gas to compensate for any leakage from the enclosure.

The system design shall be based on the following criteria:

- Indoor temperature (Anticipated design) : 21°C
- Altitude above sea level – Thabazimbi : 974 m
- Altitude above sea level – Lephalale : 820 m

A complete system and design approval shall be provided on the total inert gas installation. Approval shall be by either FM, UL, VDS or LPC. Proof of compliance with this requirement shall be by means of certified copies of the original certificates.

39.22.3.3 Storage Containers

(a) General

Containers shall be designed to hold the specific extinguishant. Containers shall not be charged to a full density greater than specified in SANS 14520 relating to the specific extinguishant. Cylinders shall be designed to suit the working pressure of the gas offered. Design pressure shall be at least 1.5 times the working pressure.

Container and valve manifolds shall be tested hydraulically to a pressure specified in SANS 14520 and be substantiated by a relevant test certificate.

All cylinders shall be supplied with a pressure relief valve as per SANS 14520 specification.

The containers used in these systems shall be designed to meet the requirements of relevant national standards, particularly the Vessels Under Pressure Regulations under the Occupational Health and Safety Act (Act 85 of 1993). The Contractor shall provide written proof of compliance with such design code by the manufacturer. Furthermore, the Contractor shall submit test certificates for each and every storage cylinder before bringing them onto Site. Where no certificates have been issued, the Contractor shall submit a list of cylinders, including manufacturer, serial number, and the date and test pressure of the latest hydrostatic test stamped on every cylinder.

All storage cylinders shall be supplied new, and all cylinders forming part the installation shall be of interchangeable without any modification whatsoever.

Cylinder shipping shall be in accordance with the design code of the cylinders.

Storage cylinders shall be shipped fully charged, and with an approved protective cap over the cylinder valve. Protective caps shall be removed only once cylinders have been finally bracketed into position.

Storage cylinders shall be installed in banks in accordance with the manufacturer's specifications and SANS 14520 Code of Practice. All cylinders shall be securely positioned by means of a rigid bracketing assembly, which eliminates any lateral movement of cylinders after installation.

(b) Contents Indication

The Contractor shall submit to the Engineer a charging certificate for every charged cylinder before commissioning commences, which confirms that charge composition is within the allowable tolerance. The charging certificate shall indicate the cylinder serial number, date of charge, location where charged, and charge contents.

Means shall be provided to indicate that each container is correctly charged.

(c) Container Arrangement

Arrangements shall be made for container and valve assemblies and accessories to be accessible for inspection, testing and other maintenance when required.

Containers shall be adequately mounted and suitably supported according to the systems installation manual to provide for convenient individual servicing of the container and its contents.

Containers shall be located as near as is practical to the enclosure they protect.

Storage containers shall not be located where they will be subjected to severe weather conditions or to potential damage due to mechanical, chemical or other causes. Where potentially damaging exposure or unauthorized interference are likely, suitable enclosure or guards shall be provided.

Different sized storage containers connected to a common manifold may be used for non-liquefied gas containers, provided they are all pressurized to the same nominal working pressure.

Manifolds manufactured shall be certified suitable and tested by inert gas agent Plant manufacturers. No manifold may be fabricated on Site or welded on Site after pressure testing is complete.

All welding on an inert gas agent manifold shall conform to SANS 044, performed by coded welders, and preferably machine welded. Suitable approved electrodes shall be used.

The Engineer retains the right to inspect, at any stage of manufacture, the welds on any manifold. This right of inspection, whether exercised or not, shall not in any way detract from the right of the Engineer of reject inferior Plant at any stage.

Where the Engineer, at its sole discretion, feels that welds may be of inferior quality, it may require of the Contractor that he performs or have performed X-ray testing of such welds, at the Contractor's expense.

Flexible connection hoses shall consist of flexible, steel reinforced hose, with swaged-on threaded connectors on either end, and shall incorporate a check valve to prevent agent loss in case of a discharge with any cylinder disconnected from the hose for any reason.

(d) Solenoid Valves

At each bank, an electrical solenoid operated control head (not detonator type) shall automatically release the gas on receipt of the appropriate fire alarm signal. Each control head shall be provided with an override manual control arm, pull-out pin and safety chain.

(e) Main Orifice

Any clean agent main orifice shall be either a clamped plate orifice or configured as a nipple, and connected on the upstream side to the manifold, and on the downstream side to the distribution pipe system. Contractors shall ensure that the orifice is installed for the right direction flow.

All main orifices shall be supplied by the ISO9001 certified manufacturer of the clean agent Plant.

The Contractor or other party shall under any circumstances be allowed to perform any drilling, machining, or other work or modification on an orifice assembly.

Any main orifice shall be certified by its manufacturer as suitable for the application intended, and a certificate submitted to the Engineer.

The main orifice shall be positively anchored to the building structure, in accordance with the requirements of the Plant manufacturer, and to the satisfaction of the Engineer, to avoid pipe movement during discharge. The Contractor shall specifically detail his main orifice fixing arrangement on his drawing submittals for approval by the Engineer.

An orifice union shall incorporate a stainless-steel orifice plate clamped between bolted clamping flanges or inside a threaded union. The orifice opening shall be drilled by the manufacturer, and the opening size clearly and indelibly stamped on the orifice assembly.

An orifice nipple shall be brass, with centre hex for assembly purposes. The orifice opening shall be drilled by the manufacturer, and the opening size clearly and indelibly stamped on the body of the nipple.

39.22.3.4 Distribution

(a) General

Pipework and fittings shall comply with the appropriate national standards, shall be non-combustible and able to withstand the expected pressures and temperatures without damage.

Before final assembly, pipe and fittings shall be inspected visually to ensure they are clean and free of burrs and rust, and that no foreign matter is inside, and the full bore is clear. After assembly, the system shall be thoroughly blown through with dry air or other compressed gas.

A dirt trap consisting of a tee with a capped nipple, at least 50mm long, shall be installed at the end of each pipe run. Drain traps protected against interference by unauthorised personnel shall be fitted at the lowest points in the pipework system if there is any possibility of a build-up of water.

Pressure relief devices, which can include the selector valve, shall be fitted so that the discharge, in the event of operation, will not injure or endanger personnel and, if necessary, that the discharge is piped to an area where it will not be a hazard to personnel.

In the systems using pressure-operated container valves, automatic means shall be provided to vent any container leakage that could build up pressure in the pilot system and cause unwanted opening of the container valve. The means of pressure venting shall not prevent operation of the container valve.

The manifolds to the containers and valve assembly shall be hydraulically tested by the manufacturer to a minimum pressure of 1.5 times maximum working pressure, or as required by the appropriate national standards.

(b) Piping

Piping shall be of non-combustible material with physical and chemical characteristics such that its integrity under stress can be predicated with reliability and designed for the pressure at maximum operating temperature but not less than 50°C. In performing this calculation, all joint factors and threading, grooving or welding allowances shall be taken into account.

Where a static pressure-reducing device is used in a non-liquefied gas system, the maximum working pressure in the distribution pipework downstream of the device shall be used in the calculation of the downstream pipe wall thickness.

Cast iron and non-metallic pipes shall not be used.

All pipes to be ASTM A 106 Grade B Seamless as specified in the relevant part of SANS 14520.

(c) Fittings

Fittings shall be designed for the pressure at maximum operating temperature but not less than 50°C when filled to the maximum allowable fill density for the extinguishant being used. For systems that use a pressure-reducing device in the distribution piping, the fittings downstream of the device shall have a minimum rated working pressure equal to or greater than the maximum anticipated pressure in the downstream piping.

Cast iron fittings shall not be used.

Welding and brazing alloys shall have a melting point above 500°C.

Welding shall be performed in accordance with relevant national standards.

Fittings to be 3000lb as specified in the relevant part of SANS 14520.

(d) Protection against Corrosion

All steelwork shall be adequately protected against corrosion. Where no specific protection has been specified, steelwork shall be painted as follows:

Surfaces shall be thoroughly cleaned in accordance with SANS 064. A zinc chromate primer complying with SANS 679 type 1 shall then be applied. Finally two coats of paint complying with Grade 1 of SANS 630 shall be applied. Colours shall be subject to approval by the Engineer.

Care shall be taken that the entire surface is covered to the same standard and where surfaces have been damaged during the installation, these shall be touched up to the same standard.

All hangers, anchors, brackets, guides and supports inside and outside building shall be treated as described above.

Nuts, bolts and screw threads shall be galvanised mild steel or brass.

Corrosion protection shall be done in compliance with the requirements of Section 37.

(e) Painting

All Plant, pipework, ductwork, supports, hangers, plinths, bars, etc., located in plant rooms and where it is visibly exposed shall be painted to a colour scheme approved by the Engineer. Items, which are protected against corrosion by other means (galvanising etc.) shall be subject to painting when located as described above.

(f) Marking of Piping and Valves

Piping shall be marked with colour coded polyvinyl chloride bands identifying contents carried and direction of flow. Band widths shall be 200 mm wide for pipes up to 250 mm diameter and 400 mm wide for larger piping.

Piping shall be marked after installation and painting has been completed.

Piping shall be marked every 10 m of pipe run, before and after bends, pipe connections to valves and Plant, where pipes leave walls, floors, ceiling and where concealed pipes are visible through access doors.

Valve tags identifying its function shall be bronzed or welded to all valves or fastened by heavy brass chains. Valve tags shall be at least 50 mm in diameter. Numbering or identification of tags shall correspond to identification on central and diagrammatic charts framed in the gas storage room and contained in operating and maintenance manuals.

(g) Labels

Labels shall be of non-corroding material, consist of white lettering with a minimum height of 4 mm on a black non-glossy background. Labels shall be screwed into position.

Labels shall be provided under each gauge, meter, pilot light, instrument, panel, switches, controllers, etc., identifying the function and set point if applicable to such Plant.

(h) Pipe Supports

Pipe and valve supports shall be suitable for the expected temperature and shall be able to withstand the dynamic and static forces involved. Due allowance shall be made for the stresses induced in the pipework by temperature variations. Adequate environmental protection shall be given to supports and associated steelwork. The distance between pipe supports shall be as specified below:

Nominal Diameter of Pipe DN	Maximum Pipework Span m
6 10	0.5 1.0
15 20 25	1.5 1.8 2.1
32 40 50	2.4 2.7 3.4
65 80 100	3.5 3.7 4.3
125 150 200	4.8 5.23 5.8

Adequate support shall be provided for nozzles and their reactive forces such that in no case shall the distance from the last support be greater than as follows:

- 25 mm diam pipe: 100 mm; and
- >25 mm diam pipe: 250 mm.

Movement of pipework caused by temperature fluctuations arising from environment or the discharge of extinguishant may be considerable particularly over long lengths and should be considered in the support fixing methods.

All pipe runs and system components shall be located to maintain a minimum clearance of 200 mm from electrical conduit or Plant, unless greater clearance is indicated on the drawings.

Where Plant is to be bolted down on concrete plinths, anchor studs shall preferably be cast into concrete bases. In such instances, the thread of the anchor studs shall be suitably protected to readily facilitate repeated disassembly of fixing assemblies.

Where Plant is to be fixed to concrete or brickwork surfaces, and where building or casting in is not feasible or desirable, fixing shall be by means of approved expansion type anchor bolts. Due care shall be taken to ensure adequate penetration of any expansion bolt, to eliminate surface damage.

All pipelines shall be firmly bracketed to walls and ceilings to the satisfaction of the Engineer. Any piping system shall be securely supported with due allowance for expansion and concentration and shall not be subject to possible damage.

The Contractor shall supply all bolts, fasteners, fittings, braces, supports, packings, gaskets, etc. necessary for assembly all Plant supplied by him. All such items required for assembly shall be supplied by the manufacturer of the clean agent Plant, or alternatively approved by the manufacturer.

Assembly of Plant shall be done in accordance with the requirements of the clean agent Plant manufacturer.

All pipe ends shall be reamed clean of any burrs before assembly. The Contractor shall physically check the inner diametral tolerance of particularly smaller pipe sizes for conformity with the specification.

The Contractor is advised to blow through all distribution pipework and nozzles to ensure that no blockages exist, prior to performing the full discharge test.

39.22.3.5 Valves

All valves, gaskets, O-rings, sealant and other valve components shall be constructed of materials that are compatible with the extinguishant and shall be suitable for the envisaged pressures and temperatures.

Valves shall be protected against mechanical, chemical or other damage.

Special corrosion-resistant materials or coatings shall be used in severely corrosive atmospheres.

39.22.3.6 Nozzles

(a) Nozzle Choice and Location

Nozzles, including nozzles directly attached to containers, shall be as supplied by the certified manufacturer of the clean agent Plant, and shall be of adequate strength for use with the expected working pressures, able to resist normal mechanical damage, and constructed to withstand expected temperatures with deformation.

All discharge nozzle orifices shall be pre-drilled by the certified manufactured of the clean agent Plant, and the equivalent single orifice size clearly and indelibly stamped on the nozzle body, regardless of shape and number of orifices. This equivalent size shall refer to the size of standard single orifice type with rounded entry and a coefficient of discharge of not less than 0.98, having the same flow rate as the nozzle in question. The Contractor or any other party shall not under any circumstances be allowed to modify in any way pre-drilled nozzle orifice.

Where possible, a minimum of two nozzles shall be provided in every protected space, or any part of subdivision separated from the main part of the protected space by any physical barrier, such as access flooring or ceiling. Single nozzles shall only be used in spaces too small to accommodate two nozzles. Where single nozzles are installed, blind elbows shall be fitted.

All discharge nozzles shall be located to achieve the best results and shall be selected and positioned that the discharge will not splash flammable liquids or create dust clouds that might spread a fire, create an explosion, or otherwise adversely affect the contents of the protected space. Nozzles vary in design and discharge characteristics and shall be selected on the basis of their suitability for the use intended.

The type number and placement of nozzles shall be such that:

- The design concentration is achieved in all parts of the enclosure;
- The discharge does not unduly splash flammable liquids or create dust clouds that might extend the fire, create and explosion or otherwise adversely affect the occupants; and
- The velocity of discharge does not adversely affect the enclosure or is content.

Where clogging by foreign materials is possible, the discharge nozzles shall be provided with frangible discs or blow-out caps. These devices shall provide an unobstructed opening upon system operation and shall be designed and arranged so they will not injure personnel.

Nozzles shall be suitable for the intended use and shall be approved for discharge characteristics, including area coverage and height limitations.

Nozzles shall be of adequate strength for use with the expected working pressures, they shall be able to resist nominal mechanical abuse and shall be constructed to withstand expected temperatures without deformation.

Nozzle discharge orifice inserts shall be of corrosion – resistant material and be brass with male threaded connections to ANSI B1.20.1, and compatible with the pipe threaded being used. The Contractor shall individually ensure that the threaded on each and every nozzle matches pipe threaded before commissioning.

(b) Nozzles in Ceiling Tiles

In order to minimize the possibility of lifting or displacement of lightweight ceiling tiles, precautions shall be taken to securely anchor tiles for a minimum distance of 1.5m from each discharge nozzle.

(c) Marking

Discharge nozzles shall be permanently marked to identify the manufacturer and size of the orifice.

39.22.3.7 Operations

(a) Gas Control Units

Gas control units shall provide the interface between the smoke detection and gas extinguishing systems. The control signals required to trigger the gas system shall be provided as part of the smoke detection system and shall be wired to the gas release valves or pilot cylinders.

Two signals from separate alarm circuits inside the area shall be necessary to activate the gas release. Activation of the break glass unit located on the gas control unit shall directly start the extinguishing cycle.

The gas control units shall have key switches for manual or automatic selection as well as an isolate switch for maintenance purposes. Dual LED’s shall indicate automatic or manual mode, gas discharge, isolate, reset and fault statuses.

The control unit shall provide the necessary outputs for gas release valves, audible and visual alarms.

Gas control units shall be equipped with break glass units in the same panel and will be installed outside the risk areas in the positions as indicated on the drawings.

(b) Approvals

- EN12094-1 Approved
- EN54-2 & EN54-4 Approved

(c) Special Features

(i) Switch Inputs

- 4 x Programmable;
- 1 x Manual Trigger; and
- 6 x Release Related (Mode select, Valve Monitor, Pressure Monitor, Hold, Abort and Flow).

(ii) USB Ports

1x USB port onboard for PC download.

(iii) Countdown Timer and LCD

Large digit countdown timer and LCD.

(iv) On Board Relays

4 x 1 A 30 V DC Relay Outputs (Fire, Fault & 2 Programmable).

(v) Event Log

1,000 event time stamped event log.

(d) Warning Notices

Warning notices shall be provided on the doors leading into the gas protected area(s) in accordance with the specifications of SANS 14520.

(e) Control Procedures

(i) With Gas Control Unit in the Automatic Mode

Release of gas will work on a double knock and coincidence basis and according to the following procedure:

The extinguishing system shall use the double knock and coincidence principle before activating the gas release valve. Two signals from separate detector circuits inside the area shall be necessary to activate the gas release.

First knock: Any HSSD detects a fire

Step 1: Activate Siren and Strobe (inside & outside room) - standard tone.

Second knock: Second HSSD detects a fire

Step 2: Activate alarm bells (inside & outside room) - intermittent tone. (Siren and Strobe still activated) – inside and outside room
Step 3: Activate evacuation signs - flashing mode.
Step 4: Close motorised dampers and stop any fresh air and air conditioning units.
Step 5: Activate pre-release timer adjustable from 20 to 120 seconds.

After pre-release period:

Step 10: Alarm Bells (inside & outside) - Solid Tone.
Step 11: Activate evacuation signs - steady on mode.
Step 12: Open gas release valve.

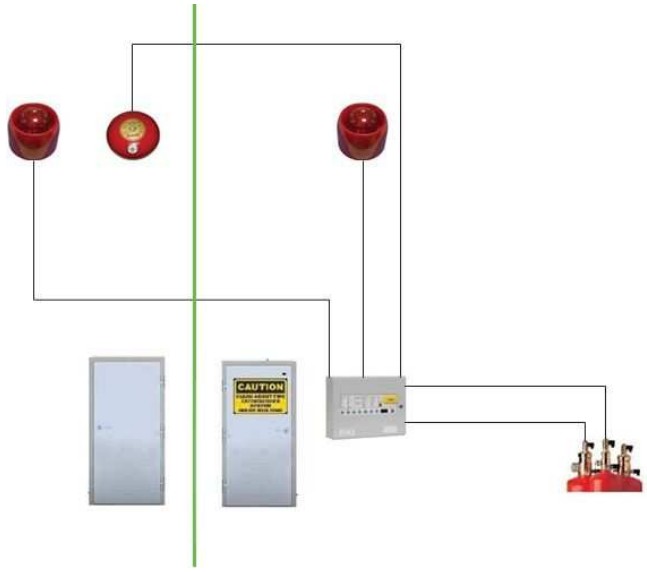
The image below shows the implementation of 2 sounder-strobe devices each on a separate sounder circuit as the 1st stage alarms devices on a gas protected area.

A bell is shown inside of the room connected to the second stage alarm (End Of Line resistor must be connected at the last device to ensure active monitoring).

The bell will be pulsed pre-discharge and remain on (solid tone) upon discharge.

Schematic below indicates the positions of the bells and sire / strobes for the gas protected rooms:

INSIDE OF ROOM **OUTSIDE OF ROOM**



AUDIBLE AND VISUAL WARNINGS FOR GAS PROTECTED AREAS						
	Bell inside	**Siren inside**	**Strobe inside**	**Siren outside**	**Strobe outside**	
First detector activates		ON	ON	ON	ON	Standard / house fire alarm
Second detector activates & timer starts	ON (intermittent)	ON	ON	ON	ON	Intermittent sound
Timer expires / Discharge	ON (solid)	ON	ON	ON	ON	Solid sound

(ii) With the Gas Control Unit in the Manual Mode

Follow steps 1 to 5 above.

No gas release shall take place in this mode

Gas release in this mode shall only be affected by either switching to the automatic mode or by activating the break glass unit on the gas control unit.

All pressure dampers shall be closed 60 seconds after a gas discharge.

(iii) Break Glass Unit Activate

Activation of the break glass unit located on the gas control unit (status panel) shall directly start steps 2 to 5 of the extinguishing cycle.

Manual release of the extinguishing gas shall always be possible by operation of the break glass unit on the gas control unit, regardless of the mode selected (manual or automatic).

All alarms shall be reported to the main fire panel.

(f) Means of System Control

The system shall be provided with:

(i) Time Delay Device

The gaseous suppression system shall incorporate a pre-discharge alarm with a time delay sufficient to allow personnel evacuation prior to discharge. Time delay devices shall be used only for personnel evacuation or to prepare the hazard area for discharge.

(ii) Automatic / Manual Switch

The system is to be provided with an Automatic / Manual switch which will allow isolation of the system and manually triggered discharge, if desired.

The Gas Control Panel shall have the ability to remotely monitor the auto / manual status of the panel via an input/output module/relay.

The auto / manual switching status will be reported to the end-user by the installed sms communicator and or through the PLC interfacing.

39.22.3.8 Visual and Auditory Warnings

Continuous visual and audible alarms at entrances and designated exists inside the protected area and continuous visual alarms outside the protected area which operate until the protected area has been made safe are required.

These shall be provided in strict accordance with the requirements of SANS 14520 Code of Practice.

39.22.3.9 Instructions for Use

Instructions shall consist of:

- Notices, certificates, diagram, etc., and all notices as required by the SANS 14520 Code of Practice;
- Schematic layout of all systems on which all Plant, control devices and instruments are correctly indicated for that particular plant room. Diagrams shall contain information on set differential bands, throttling ranges, time delays, overload settings and other relevant data necessary for the checking and adjusting of each instrument, control and motor function;

- Wiring diagrams; and
- Detailed instructions for working of the system / Plant.

Instructions shall be printed on high quality, non-deteriorating paper framed behind glass.

39.22.3.10 Post Discharge Venting

No post discharge venting is to be allowed for.

39.22.3.11 Proximity to Electrical Hazards

Where exposed electrical conductors are present, clearances no smaller than those given in the table below shall be provided, where practicable, between the electrical conductors and all parts of the system that may be approached during maintenance. Where these clearance distances cannot be achieved, warning notices shall be provided and a safe system of maintenance work shall be adopted.

Maximum Rated Voltage kV	**Minimum Clearance From Any Point On Or About The Permanent Plant Where A Person May Be Required To Stand**	
	To The Nearest Unscreened Live Conductor In Air (Section Clearance) m	**To The Nearest Part Not At Earth Potential Of An Insulator Supporting A Live Conductor (Ground Clearance) m**
15	2.6	2.5
33	2.75	
44	2.90	
66	3.10	
88	3.20	
110	3.35	
132	3.50	
165	3.80	
220	4.30	
275	4.60	

39.22.3.12 High Sensitivity Smoke Detection (HSSD)

(a) General

A High Sensitivity Smoke Detection System shall be installed in all areas.

The system shall consist of a highly sensitive laser-based smoke detector using aspirated air sampling and is connected to sampling pipes. It shall be provided with a single sample pipe inlet, internal flow monitoring, smoke detection and a facility for exhaust pipe connection.

Reset, disable, test and fault determination functions shall be available via the field service access door. System configuration will be provided through Auto Learn Smoke and Flow functions, also available via the field service access door.

The system shall support pre-engineered sampling pipe network designs with verified calculations in addition to custom sampling pipe network designs using a computer-based design modelling tool. Sampling pipe material shall be UL 1887 approved for use in air sampling smoke detection systems and shall be red in colour.

(b) Approvals

The High Sensitivity Smoke Detection System must be of a type submitted to, tested, approved, and/or listed by nationally recognized testing laboratories as follows:

i) UL (Underwriters Laboratories Inc).
ii) ULC (Underwriters Laboratories Canada).
iii) FM (Factory Mutual).
iv) FM approved for Hazardous Locations, Class 1, Div.2, Groups A, B, C, D (3020906).
v) CSFM (California State Fire Marshall).
vi) LPCB (Loss Prevention Certification Board).
vii) ActivFire.
viii) VdS (Verband der Sachversicherer e. V.).
ix) AFNOR.
x) VNIIPO.
xi) CFE.
xii) KFI.

(c) Codes, Standards or Regulations

The smoke detection system shall be installed to comply with one or more of the following codes or standards:

- AS 1670.1-2004, AS1603.8 – 1996, ASNZS 3000;
- Fire Industry Association (FIA), Code of Practice for Design, Installation, Commissioning & Maintenance of Aspirating Smoke Detector (ASD) Systems;
- NFPA Standards, US;
- NEC Standards, US;
- NZS 4512 : 2003; and
- Relevant South African codes and standards.

(d) Aspirating Detector

In addition to the 'CCD' primary sensor and 'SCD' supplementary sensors within the detector, the following facilities and functions shall also be provided:

- Inbuilt 7" colour touch screen multi-function, multilingual LCD;
- Combined Fire & Smoke (CFS) particle level status 'dial';
- CCD particle level status 'dial';
- SCD particle level status 'dial';
- 4 x programmable alarm points and output contacts for Pre-alarm, Fire 1, Fire 2 & Fire 3 per pipe;
- LCD & LED status indication of Pre-alarm, Fire 1, Fire 2 and Fire 3 (per pipe if required);
- LCD & LED status indication of 'Common Fault' and 'Power Healthy';
- Detector 'Silence' and detector 'Reset' buttons;
- Individual pipe 'High Airflow' and 'Low Airflow' fault monitoring status 'dials';
- CFS & alarm level sensitivity setting screen;
- 5 x Programmable output contacts for Fault, Pre-Alarm, common Fire 1 signal, common Fire 2 signal, common Fire 3 signal, Pipe 1 Fire, Pipe 2 Fire, Pipe 3 Fire and Pipe 4 Fire;
- 'HYBRID' double knock (dual technology particle increase) programmable output;
- 'Optical' signal only programmable output;
- Cirrus Hybrid Optical Settings for optical % pre-alarm (common) and fire trigger points (common or per pipe) when CCD sensor increases;
- 3 x Programmable input contacts for Isolate, Reset, Fault, Gain Set, Battery Fault band Mains Fault;
- 7 day day / night mode programmable menu function;
- Detector Text;
- Pipe Text;
- Alarm Text;
- Programmable User and Engineer access codes;
- IP Network configuration screen;
- 10 minute 'Real-time' particle data graph;
- 30 day 'Historic' particle data graph;
- 24,000 event data logging facility;
- Live camera stream from up to 6 no. IP cameras;
- 'Detector Tour' product training animation;
- 'Engineers Fault Finding Assistant' training animations;
- PDF format 'Pipe Plan' images to indication pipework configuration;
- Programmable On/Off detector audible buzzer;
- Up to 4 x 'Individual Identifiable' sampling pipe 'Inlet' ports;

- Single sampling pipe ‘Exhaust’ port;
- Support 25mm dia. sampling pipe configuration (subject to sampling pipe calculation program);
- In-built Protocol loop interface;
- In-built TCP / IP network interface; and

  RS485 Network configurable with other Aspirating Detectors (Repeat, Display, Programmer).

The aspirating detector must contain two separate detection elements to detect two different phenomenon associated with fire (fire particles and smoke particles). The detector shall include as its primary sensor a ‘Cloud Chamber’ fire detector. This is supplemented by high sensitivity ‘Optical’ detectors provided within each of the four detector sampling ports.

The cloud chamber detector (CCD) must be capable of recognising the normal quantity of invisible airborne sub-micron particles within each of the protected areas, and to detect an abnormal or significantly higher quantity of these sub-micron particles produced from combustion, electrical arcing or overheating. The cloud chamber detector must have the capability of detecting invisible particles ranging in size from 0.0025 to 10 microns.

The cloud chamber detector must not be responsive to false alarm conditions resulting from ordinary dust, moisture / condensation (water vapour), air currents (change in air pressure and/or velocity) or ambient thermal changes.

The cloud chamber measurement scale is in Particles per cm^3 (PPCC) and provides the ‘Fire’ detection element of the Cirrus HYBRID detector.

High sensitivity LED Optical ‘Scatter Chamber Detectors’ (SCD’s) shall be provided within the Cirrus HYBRID detector to each of the connected sampling ports, providing high sensitivity smoke detection per pipe. Each SCD smoke sensor shall identify the visible smoke particles generated as material over-heats.

The optical measurement scale is % obscuration per meter (%obs/m) and provides the ‘Smoke’ detection element of the Cirrus HYBRID detector.

For combined fire and smoke detection, the CCD and SCD detectors shall operate both independently from each other and through the use of complex algorithms operate together, to provide intelligent alarm decision making.

The synergy of these two technologies shall provide an aspirating detector that can verify true fire / smoke alarm conditions and can discriminate unwanted or false alarms which can cause false alarms to optical only aspirating detectors.

The detector shall indicate both of the two separate detection element scales (PPCC & %obs/m) independently and also display these two scales on a bespoke scale known as Combined Fire and Smoke (CFS) as the primary display.

The detection system shall be listed and approved to cover up to 250m².

The detection system shall be approved to provide very early warning smoke detection and provide up to four output levels corresponding to Alert, Action, Fire 1 and Fire 2.

The detector shall provide fault indication on the unit using the Instant Fault Finder function.

The detector shall be self-monitoring for filter contamination.

The detector shall provide staged airflow faults via the use of an ultrasonic flow sensor in the pipe inlet port.

(e) Submittals

Product data and site drawings shall be submitted and shall include pipe layout, operational calculations and performance criteria.

A copy of the manufacturer's installation, operation and maintenance manuals shall be supplied upon completion of the installation.

System commissioning data shall be supplied (in a format recommended by the manufacturer and per the instructions provided by the manufacturer) within 30 days of completion of the installation.

39.22.3.13 Quality Assurance

(a) Qualifications

(i) Manufacturer

The manufacturer shall have a minimum of 15 years production experience in the manufacture and design of high sensitivity air sampling smoke detection systems.

The manufacturer shall be certified as meeting ISO 9001:2008 for manufacturing.

(ii) Technology

The Laser Detection Chamber shall be of the mass Light Scattering type and capable of detecting a wide range of smoke particle types of varying size.
A smoke-hours method shall be used for the purpose of monitoring contamination of the filter (dust & dirt etc.) to automatically notify when maintenance is required.

The Laser Detection Chamber shall incorporate a separate secondary clean air feed from the filter, providing clean air barriers across critical detector optics to eliminate internal detector contamination.

The detector shall not use adaptive algorithms to adjust the sensitivity from that set during commissioning. A learning tool shall be provided to ensure the best selection of appropriate alarm thresholds during the commissioning process.

(iii) Plant Supplier

The Plant supplier shall be authorized and trained by the manufacturer to calculate / design, install, test and maintain the air sampling system and shall be able to produce a certificate stating such on request.

(b) Detector Assembly

The Detector, Filter, Aspirator and Relay Outputs shall be housed in a mounting box and shall be arranged in such a way that air is drawn from the fire risk area and a sample passed through the Dual Stage Filter and Detector by the Aspirator.

The Detector shall be laser-based type and shall have an obscuration sensitivity range of 0.0025-20% obs/m.

The Detector shall have four independent field programmable smoke alarm thresholds across its sensitivity range with adjustable time delays for each threshold between 0-60 seconds.

The detector shall also incorporate the facility to transmit a fault either via a relay.

The detector shall have a single pipe inlet that must contain an ultrasonic flow sensor. High flow fault (urgent and non-urgent) and low flow fault (urgent and non-urgent) can be reported.

The filter must be a two-stage disposable filter cartridge. The first stage shall be capable of filtering particles in excess of 20 microns from the air sample. The second stage shall be ultra-fine, removing more than 99% of contaminant particles of 0.3 microns or larger, to provide a clean air barrier around the detector's optics to prevent contamination and increase service life.

The aspirator shall be a purpose-designed aspirator assembly.

When using pre-engineered sampling pipe networks shall be capable of supporting combined sampling pipe length up to 100m with a transport time per applicable local codes. Custom sampling pipe network designs shall be supported using calculation software.

The assembly must contain relays for basic alarm and fault conditions. The relays shall be software programmable (latching or non-latching). The relays must be rated at 1A at 30 VDC.

The assembly shall have built-in event and smoke logging. It shall have separate event log storage for smoke levels, alarm conditions, operator actions and faults. The date and time of each event shall be recorded. Each detector (zone) shall be capable of storing up to 128 events on a First In First out (FIFO) basis.

(c) Displays

The detector shall be provided with LED indicators and Touchscreen display.

Each Detector shall provide the following features at a minimum:

- Alert, Action, Fire 1 and Fire 2 corresponding to the alarm thresholds of the detector;
- Circular Smoke Dial display to represent the level of smoke present in protected area;
- Fault indicator;
- Power indicator;
- Disabled indicator; and
- Buttons supporting the following features shall be accessible to authorized personnel:
    - Reset – (press and release) un-latches all latched alarm and faults;

- Disable – (press and release) disables the fire relay outputs from actuating and indicates a fault; and
- Test – (press and release) simulates a Fire 1 condition.

(d) Digital Communication Port

An RS485 compatible serial port shall be provided on the detector for configuration, status monitoring, command input, event log extraction and software upgrades. It shall comply with EIA RS485Protocol.

The unit shall support an Open Detector Control Protocol (ODCP) for connection to 3rd party embedded devices. The ODCP shall provide the following:

- Alarm Status for all VLF alarm levels;
- Current smoke level;
- Current flow level (% flow and litres/min);
- Detector state (Running, Disable & Standby);
- Fault Status;
- Remaining Days for Filter Life;
- Smoke Threshold levels;
- Detector's product ID (serial number);
- Reset;
- Disable;
- Standby;
- Normalise; and
- Set smoke thresholds.

(e) Detection Alarm Levels

The standard laser-based air sampling detection system shall be supplied with two alarm relay outputs (Alert and Fire 1). For four-relay alarm levels use the optional relay interface card.

The standard alarm outputs may be used as follows:

- Alert (Alarm Level 1)

  Activate a visual and audible alarm in the fire risk area.

- Action (Alarm Level 2)

  Activates the electrical / electronic Plant shutdown relay and activates visual and audible alarms in the Security Office or other appropriate location.

The additional alarm outputs, with the optional relay interface card may be used as follows:

- Fire 1 (Alarm Level 3)
  Activate an alarm condition in the Fire Alarm Control Panel to call the Fire Brigade and activate all warning systems; and

- Fire 2 (Alarm Level 4)
  Activate a suppression system and/or other suitable countermeasures (eg. evacuation action or shutdown of systems).

(f) Initial Detection Alarm Settings

Initial settings for the alarm levels shall be determined by the requirements of the fire zone. Default settings of the unit shall be:

- Alarm Level 1 (Alert) 0.08% obs/m (0.0025% obs/ft);
- Alarm Level 2 (Action) 0.14% obs/m (0.0448% obs/ft);
- Alarm Level 3 (Fire 1) 0.20% obs/m (0.0625% obs/ft); and
- Alarm Level 4 (Fire 2) 2.0% obs/m (0.625% obs/ft).

(g) Initial (Factory Default) Alarm Delay Thresholds

Initial (factory default) settings for the alarm delay threshold shall be:

- Alarm Level 1 (Alert) : 10 seconds;
- Alarm Level 2 (Action) : 10 seconds;
- Alarm Level 3 (Fire 1) : 10 seconds;
- Alarm Level 4 (Fire 2) : 10 seconds; and
- Fault Alarm : 5 seconds.

(h) Fault Alarms

The Detector Fault relay shall be connected to the appropriate alarm zone on the Fire Alarm Control Panel (FACP) in such a way that a Detector Fault would register a fault condition on the FACP. The fault relay shall also be connected to the appropriate control system.

(i) Power Supply and Batteries

The system shall be powered from a regulated supply of nominally 24V DC. The battery charger and battery shall comply with the relevant Codes, Standards or Regulations. Typically 24 hours standby battery backup is required followed by 30 minutes in an alarm condition in accordance with EN 54: Part 4.

39.22.3.14 Sampling Pipe Design

(a) Sampling Pipe

The Contractor shall ensure that the proposed air sampling system design for the area(s) to be protected, complies with the recommendations and product approvals, with regard to the maximum number of sample points, maximum lengths of sampling pipes and the maximum area of coverage per sampling point and/or detector.

The sampling pipe network design for each installation must be submitted to the Engineer for approval. The design details given to the aspirating system designer shall indicate materials of construction, sampling pipe type, size and lengths together with 'Sampling Point' and 'Capillary Sampling Point' hole spacing and size.

Any significant design deviation may alter the operation of the system and therefore any adjustment of the air sampling network design must be submitted to the Engineer for approval.

The Contractor shall ensure that the aspirating system sampling pipe work configuration is confirmed as acceptable using the applicable sampling pipe calculation program. The calculation program shall determine the transport times, airflow and balance details for each individual sampling pipe and sampling point.

The maximum 'transport time' must not exceed 120 seconds or 60 seconds (Class A response time) from the furthest sampling point on the pipe work system to the aspirating detector.

Where appropriate the Contractor shall include within their design / installation sampling pipe 'test points'. These will be installed at the end of each sampling pipe run after the last sampling point. These test points are provided for future system servicing and to test the integrity of the sampling pipe from the furthest point back to the aspirating detector. Test points should be located within accessible and secure areas to prevent tampering by unauthorized personnel. It is not a requirement for the sampling pipe test point to comply with the maximum transport time of 120 seconds or 60 seconds (Class A response time).

The sampling pipe shall be smooth bore. Normally, pipe with an outside diameter (OD) of 25mm and internal diameter (ID) of 21mm shall be used.

The pipe material shall be suitable for the environment in which it is installed or should be the material as required by the specifying body (UL 1887 Plenum rated CPVC).

All joints in the sampling pipe must be airtight and made by using solvent cement, except at entry to the detector.

The pipe shall be identified as Air Sampling / Aspirating Smoke Detector Pipe (or similar wording) along its entire length at regular intervals not exceeding the manufacturer's recommendation or that of local codes and standards.

All pipes should be supported at not less than 1.5 m centres, or that of the local codes or standards.

The far end of each trunk or branch pipe shall be fitted with an end-cap and made air-tight by using solvent cement. Use of an end-cap will be dependent on detailed calculations.

All sampling pipes shall be red in colour.

(b) Sampling Holes

Sampling holes shall not be separated by more than the maximum distance allowed for conventional point detectors as specified in the local codes and standards. Intervals may vary according to calculations.

Each sampling point port shall be identified.

Consideration shall be given to the manufacturer's recommendations and standards in relation to the number of sampling points and the distance of the sampling points from the ceiling or roof structure and forced ventilation systems.

Sample port size shall be as specified by detailed calculations.

39.22.3.15 Installation

(a) The Detection system

The Contractor shall install the system in accordance with the manufacturer's System Design Manual.

(b) The Capillary Sampling Network

Where false ceilings are installed, the sampling pipe shall be installed above the ceiling, and Capillary Sampling Points shall be installed on the ceiling and connected by means of a capillary tube.

The typical internal diameter of the capillary tube shall be 5mm, the maximum length of the capillary tube shall be 8m unless the manufacturer in consultation with the Engineer have specified otherwise.

The Capillary tube shall terminate at a Ceiling Sampling Point specifically designed and approved by the manufacturer. The performance characteristics of the Sampling Points shall be taken into account during the system design.

(c) Air Sampling Pipe Network Calculations

For specific performance requirements that fall outside the pre-engineered designs, a sampling pipe aspiration-modelling program shall provide air sampling pipe network calculations. Pipe calculations shall be supplied with the proposed pipe layout design to indicate the following performance criteria:

(i) Transport Time

Wherever possible the transport time (i.e. the time taken by smoke sampled to reach the detector) for the least favourable sampling point shall be less than 60 seconds for open hole sampling and less than 90 seconds for capillary tubes.

(ii) Balance %

The sample point balance for the pipe shall not be less than 70%. That is, the volume of air drawn from the last sampling point shall not be less than 70% of the average volume of air through the other holes.

(iii) Commissioning Tests

The Contractor shall allow for the manufacturer's representative to attend commissioning of the entire installation in the presence of the owner and/or its representative.

All necessary instrumentation, Plant, materials and labour shall be provided by the Contractor.

The Contractor shall record all tests and system calibrations and a copy of these results shall be retained on site in the System Log Book.

A wire burn test is required during the commissioning and handing-over of the HSSD systems and shall be demonstrated to the Engineer.

(d) System Checks

Visually check all pipes to ensure that all joints, fittings, bends, sampling points, etc., comply with the Specification.

Check the system to ensure the following features are operational and programmed in accordance with the specification.

- Alarm threshold levels (for both day and night settings);
- Detector address;
- Time and date;
- Time delays;
- Air flow fault thresholds;
- External buttons operable (Reset / Disable / Test / Instant Fault Finder, AutoLearn Smoke and AutoLearn Flow);
- Referencing (if VESDAnet card is used; and
- Units set to U.S./S.I. (for US only) or metric for other regions

Check to ensure that all ancillary warning devices operate as specified.

Check interconnection with Fire Alarm Control Panel to ensure correct operation.

(e) Tests

Introduce smoke into the detector assembly to provide a basic Go / No-Go functional test.

Verify that transport time from farthest sampling port does not exceed the local code requirements.

Activate the appropriate Fire Alarm zones and advise all concerned that the system is fully operational. Fill out the logbook and commissioning report accordingly.

This shall be read in conjunction with Section 48.

39.22.3.16 Addressable Detection Control Panel

(a) Panel Description

The fire alarm panel shall be a 24 volt analogue addressable unit, designed to communicate with the sensors and field devices. It shall be a microprocessor based unit, and shall incorporate all hardware and software to enable it to make decisions based upon information received from sensors, and operate appropriate outputs to initiate required alarms and signals.

The fire detection and alarm system shall be manufactured by an ISO 9001:2008 certified company and meet the term and definition in BS EN ISO 13943 and the following shall apply:

- The CIE (Control and Indicating Plant) and peripheral devices shall be manufactured by a single manufacturer, and;
- The CIE and peripheral devices shall be approved to the latest EN standard by an industry recognized and reputable third-party test house such as LPCB, BSi etc.

The fire alarm control panel shall continually collect and analyze the required device data to enable it to make the final decision on whether a fire or fault exists by the use of algorithms. The operational principle of the system shall be on a true addressable / intelligent basis, utilizing algorithms in the panel to minimize the risk of false alarms, the programming software should give the flexibility to change these algorithms depending on the ambient conditions for the detector.

The fire detection control panel shall include the benefit of Addressing utilising Firmware Addressed Secure Technology (FAST) utilising barcodes, the system shall also overcome the limitations of Hard Addressing procedures. If devices are added or removed at a later point, all the existing devices in the loop must keep the same address, zone and text location.

The Control Panel shall log the addresses and have the facility to map to a physical address, unique device barcode shall be used to ensure that it is impossible for two devices to have the same address.

The panel shall comply fully with standard EN54: Part 2 and Part 4.

The fire alarm control panels shall be of a modular design complying with EN54 Part 2:1997 +A1:2006 and EN54 Part 4:1997 +A1:2002 + A2:2006 and facilities shall be provided to constantly monitor and check the following circuits and fault conditions, and to give the following features:

a) The power supply to the loop(s);

b) Battery impedance to be checked every 4 hours;

c) Open-circuit, short-circuit, earth fault and any other fault condition in the loop wiring;

d) Communication failures and errors in all cards and loops;

e) Monitoring of all devices status to create a table of each analogue channel for event analysis;

f) All devices i.e., Optical / Heat Sensor, Fire Alarm Interface Units, Manual Call Points, Sounders etc. shall be installed on the same loop and all interface operating relay / switch devices, auxilliary relays (controlling remote plant items, door release units etc) be monitored for faults;

g) The FACP shall support loop powered and networked repeaters. Network repeaters shall have a large, colour, interactive, touch sensitive, backlit, 800x480 viewable LCD screen. Repeaters shall be programmable as passive (indication only) or active (indication and control) and must be equipped with EN54 Part t4:1997 +A1:2002 + A2: 2006 approved power supplies;

h) The addressable device Labelling procedure may be carried out either by using the inbuilt touch screen display of the FACP or by the use of a PC based dedicated software;

i) All events, i.e. Fire, fault or warning, shall be recorded with time, date and place of occurrence in the memory event log of the Fire Alarm Control Panel. These events may either be displayed on the control panel Liquid Cristal Display (LCD), transferred electronically to PC or printed, as may be required;

j) Provision shall be available for the fire alarm control panel to silence the loop powered alarm sounders but maintain visual indication until the system is reset;

k) The facility to introduce / change delay periods in operating loop powered individual sounders or groups of sounders, shall be available to be programmed without the need to change any hardware;

l) The facility shall be available to network up to 160 Fire Alarm Control Panels using a secure RS485 network; and

m) The control unit shall have a front panel comprising of indicating LED's, control keyboard, and touch screen Liquid Cristal Display (LCD), as described in detail later.

The system will comprise **six (6)** networked panels each having **four (4)** loops. The zones must be fully field programmable to permit sensors to be allocated to any zone. The zoning must be manually configured on system start-up, or on request by an authorised operator.

(b) Panel Components and Devices

(i) Main Fire Alarm Control Panel

The control panel shall be processor controlled using intelligent analysis techniques to detect smoke / heat / fire conditions. The control panel shall be complete with, but not limited to, the following elements and shall be approved to the latest EN54 Pt2:1997 +A1:2006 and EN54 Pt4:1997 +A1:2002 + A2:2006 by an industry recognized and reputable European third-party test house (LPCB, BSi etc.).

- A large colour interactive, touch sensitive, backlit, 800x4800 viewable LCD screen capable of accessing the comprehensive range of programming and operating functions of the FACP through its touch screen Qwerty keyboard;
- The Panel must have a total of 100 inbuilt Fire Zone LED indicators as required by BS5839 Pt1:2013;
- An inbuilt 40 character thermal printer operating through a window. There shall also be an option to enable the printer when the door is closed;
- A touch screen qwerty keyboard to enable labelling of devices descriptions and any correction in label if required;

- The system shall include an Integral sealed lead acid battery and charger, with the ability to provide a minimum of 24 hour back up in normal operation and half an hour full alarm load in the event of supply mains failure;
- Fire, Fault, Warning and Power LED indicators;
- Simple menu driven functions with passcode protection shall allow users to access an extensive range of software based features such as:
  - i) An event log showing at least the last 9,999 events;
  - ii) A facility to Replace and Add devices via the Touch Screen;
  - iii) Logs of current faults and fires;
  - iv) Graphical analysis of Intelligent sensor information;
  - v) The facility to enable or disable sensors, zones, sounders, interface units.
  - vi) Addressable device status;
  - vii) Printer status to allow 'On Request' or 'Auto with filtering' options;
  - viii) Check Config facility to identify device type mismatch and to pinpoint loop open and short circuit faults;
  - ix) The Fire Alarm Control panel shall be capable of controlling the volume and tone of all addressable Loop powered sounders; and
  - x) The Fire Alarm Control Panel must have the flexibility to pulse the addressable device led status indicators during normal operation, or to withhold normal operation indication. This feature must be programmable by the touch screen at access level 3;
- The Fire alarm control panel must be capable of supporting up to 1Amp addressable loop current per loop enabling loop powered sounders, VADs, beacons and speech sounders;
- The fire alarm control panel shall support Voice Alarm Sounders to replace loop powered sounders in certain applications with up to 15 pre-programmed message / tones, selected by the panels cause and effect programming;
- The control and indication touch screen display shall be accessible via a log in code;
- Each loop shall support a maximum of 200 Intelligent Addressable devices per loop, utilising a 2 core screened fire resistant cable (cable length shall be determined by manufacturers loop loading calculator);
- A RS232 based computer based graphics facility shall be available from the panel;
- The control panel shall provide a minimum of 2 Master alarm sounder circuits (3 sounder circuits) operating at 24V DC with a maximum capacity of 1 A per circuit (500 mA if a EN54Pt13 system is selected);
- The system shall provide a secure networking facility to indicate a remote zone number and remote zone text across the network; and
- In addition to the above, all other necessary controls, elements and accessories shall be included to provide a complete and efficient panel conforming to the requirements of BS.5839, BS.5445: Part 1 and BSEN54-2 A1:2006 and BSEN54-4 A2:2006.

(c) Panel Operation

Four levels of access into the system menu via the keypad shall be provided.

These are to be as follows:

- Level 1 : Operating (no access code required)
- Level 2 : Maintenance Technician (access code required)
- Level 3 : Commissioning (access code plus key)
- Level 4 : Access Code Changes (access code plus key)

Facilities for “locking-off” controls shall be provided.

The panel is to incorporate a keyboard and push-button with the following functions:

- Numeric keyboard;
- System reset button;
- Alarm accept button / silence alarm button;
- Alarm sound button;
- Panel buzzer “mute” button;
- Lamp test function;
- Control buttons as required for system operation; and
- Menu functions for maintenance and commissioning.

(d) Polling

The system is to incorporate a polling system which polls each sensors individually and reads information at regular intervals to the control unit. The idle value shall be continuously updated in order to compensate for ageing and atmospheric conditions. The panel shall make decisions based upon the number of devices attached to the loop.

All communication shall be under the control of the panel, which shall sequentially poll each device in turn and authorise communication. No device shall communicate with the control panel without authority.

The control panel must be able to read information from a device or send instructions to a device. The panel shall monitor each device on every scan, and give a fault signal for any of the following conditions, within 30 seconds:

- Detector removed;
- Address unit removed;
- Incorrect device type; and
- Faulty calibration or sensitivity

(e) Calibration

The system must check the calibration of each analogue line device and record changes caused by environmental contamination.

When maximum calibration adjustment is reached the panel must indicate a “maintenance” signal. This must be a dedicated signal, and must be separate from the pre-alarm” signal.

The build-up of dirt or similar contamination on the optical surface will cause the output signal from the detector to gradually change. The control panel shall be capable of monitoring this slow change in signal and at a predetermined level indicate that the detector is in need of servicing.

(f) Panel Display

All display and indicators shall be LCD for text, and LED for lamp indication.

The type, calibration, sensitivity and status of each device must be able to be displayed at the control panel.

The control panel shall be able to physically identify the zone in which each sensor or device address resides and shall give a “configuration-fault” signal if a sensor or device address is located in the incorrect zone.

Fire indication shall be by zone, displayed on LED indicators, and on the LCD text display.

Fault, maintenance, pre-alarm, and device / zone disabled signals shall be indicated visually by LCD text display, and audibly, in the control unit.

The top portion of the LCD text display shall always show the first alarm received. The lower portion of the LCD text display shall show the last alarm received. It must be possible to manually scroll through all alarms on the lower portion of the screen, using “up” and “down” scroll buttons.

The display must show the total number of alarm events currently in the system.

Fire alarm shall take priority when displaying. However, it must be possible to view all events currently in the system, displayed devices, and other events.

It shall be possible to view the devices, by address, that initiated the alarm on the LCD text display, on manual request. When viewing the device, a 40 character location message specific to each device shall be displayed.

The visual indications must be arranged so that the different warnings are clearly distinguished. (I.e. amber for fault , red for alarm).

The internal audible signal device may be the same for all alarms, but either tone variation or time switching shall be used to differentiate the signals.

Outputs shall be provided for audible alarms, control functions, remote mimics and connection for computers and printers.

The LCD text display must be able to simultaneously display a minimum of the following information in each display mode.

One display mode:

- type of alarm
- 2 zones (first and last)
- alarm count
- total number of alarms
- Minimum of 40 character zone location message for each zone
- time and date

Device display mode:

- type of alarm
- 2 zones (first and last)
- alarm count
- total number of alarms
- 40 character zone location message for each zone
- time and date

Device display mode:

- loop number, zone number, detector address
- alarm count
- detector in alarm
- alarm type
- active or accepted
- time and date

The LCD must be at least a 160 character display.

(g) Software Algorithms

The data from which sensor must be evaluated by intelligent software algorithms to identify the presence of fire or smoke, and any possible faults present.

The system must support a number of software different algorithms, each tailored to suit the profile of a different hazard or protected area. These algorithms must be specifically matched to provide the optimum protection for each type of area. It must be possible to allocate selected algorithms independently to each sensor in the system. In addition, different algorithms must be automatically allocated to the same sensor at different times.

It must be possible to customise algorithms to take into account special conditions that may exist in certain specific hazards. This customisation should incorporate the features below.

Alarm sensitivity relative to each analogue detector is to be individually adjustable, device by device, by the control panel. Not less than four levels of sensitivity adjustment are required for each device, as follows:

- Smoke sensors
  - (1) 1.5%/m obs
  - (2) 2.5%/m obs
  - (3) 3.5%/m obs
  - (4) 5.0%/m obs
- Heat sensors
  - (1) 42 °C
  - (2) 58 °C
  - (3) 70 °C
  - (4) 82 °C

(h) Alarms

There shall be no limit to the number of devices which may be in alarm simultaneously.

Every analogue detector must have the facility for verifying the validity of an alarm signal over a 20 second period, before initiating an alarm. This alarm verification function must be able to be enable or disable, on a device by device basis, from the control panel.

(i) Alarm Outputs

The panel must incorporate two monitored audible alarm outputs for the switching-on of bells of electronic sounders.

These outputs must be continuously monitored for open and short circuit.

Each output must be rated at 0.75 A at 24V DC.

It shall be possible to independently display either of the alarm bell output by means of a control push button.

A test facility shall be provided in order to test each of the alarm bell out outputs. When the test is initiated the selected alarm bell will operate intermittently.

Both the alarm bells will have a delay facility which is selected by controls on the front panel. Manual call points will override this delay.

(ii) Alarm Contacts

One voltage free change-over contact must be provided. This must operate on a “fire” condition, and is to remain “on” until the system is reset.

The contacts are to be rated 2 A at 24 V DC.

(iii) Double-Knock (Coincidence) Operation

It shall be possible to programme any of the control outputs or addressable relays to operate upon an alarm from any two sensors in the programmed group.

(iv) Silencing Operation

It shall be possible to programme any of the control outputs or addressable relays to operate in either “silencing” mode or “non-silencing” mode.

In “silencing” mode the relay or outputs shall de-activate when the “alarm accept” button is pressed, or when the “reset” button is pressed, or when the “reset” button is pressed.

In “non-silencing” mode, the relay or output shall be de-activated only when the “reset” button is pressed.

(i) Activation Delay

It shall be possible to programme any of the control outputs or addressable relays to activate after a delay period from receipt of the control signal.

This delay shall be 0-16 minutes, in one second increments.

(j) Software Control

All the above functions, shall be under software control, and programmed through the panels keyboards or by means of a computer.

It must be possible, as an option, to programme the panel off-line on a computer, and download the programme into the panel.

It must be possible to save the programme to disk for future reference.

(k) Remote Panel Outputs

An optional serial port shall be provided for connecting to remote panels and computers.

The remote units must have the following display and controls:

Remote 160 character LCD text display which repeats all events being displayed on the panel display.

- numeric keyboard;
- system reset button;
- alarm accept button / silence alarm button;
- alarm sound button;
- panel buzzer “mute” button;
- lamp test function;
- “help” button;
- control buttons as required for system operation; and
- menu functions for maintenance and commissioning.

(l) Processor Monitoring

The panel must be provided with fault tolerance enabling monitoring and resetting of the microprocessor in the event of microprocessor failure. For diagnostic purposes, a counter must allow the viewing of the incidents that the processor has been reset by the system. This information must be stored in non-volatile memory, enabling it to be viewed even if the panel has been turned off. The counter must only be able to be reset by an authorised engineer, under a level 3 access code.

The microprocessor must perform full diagnostic tests on all memory devices on start-up, as follows:

- RAM Test (running data)
- EPROM Checksum Verification (programme storage)
- EEPROM Checksum Verification (site configuration storage)

Should any test fail an audible and visual fault indication must be given, and the LCD display must indicate the nature of the fault.

The control unit shall perform periodic checksum tests, at intervals not exceeding 60 minutes, on the RAM, EPROM, EEPROM memories, and give and audible, visual, and LCD text fault indication in the event of a discrepancy.

It must be possible to view the original and current checksums for all memories on the panel LCD display, as a maintenance (Level 2) function.

In the event of a fault condition where the processor will not restart within 20 seconds, the panel must give an audible and visual alarm indication.

(m) System Maintenance

The control panel shall keep statistics for each of the system sensors. These statistics shall be able to be displayed on demand by a level 2 operator.

The following statistics shall be displayed:

- Maximum value attained by the sensor as well as the date and time;
- The minimum value attained by the sensor as well as the data and time;
- The average idle value attained by the sensor; and
- Communication error rate.

It shall be possible to put up to 1 Zone (20 detectors) in soak test mode. Sensors in soak test mode will log their conditions in the vent buffer without raising fire alarms. It shall be possible to display or printout the result of the soak-test.

39.22.3.17 Gas Control Panel

The gas control panel / gas discharge panel shall be an Advanced TC3001 Advanced 3 Zone combination panel.

- The panel shall comply fully with standard EN54: Part 2;
- EN12094-1 Approved *f* EN54-2 & EN54-4 Approved *f* ;
- Full CPD Approval;
- 1,000 event time stamped event log;
- Software Extraction Tool for Downloading Configuration and Event Logs;
- Large LCD / Digit Countdown Timer; and
- On Board Relays : 4 x 1 A 30 V DC Relay Outputs (Fire, Fault & 2 Programmable)

39.22.3.18 Detector Bases

Sensors must plug into separate mounting bases with a twit-lock action. The bases shall be fitted with corrosion resistant connector springs and terminal screws with captive clamping plates.

All bases shall incorporate a concealed security lock to prevent unauthorised removal of tampering with sensors. It shall be possible to activate the security lock in areas where required. With the security lock activated, it must only be possible to remove a sensor from its base using a special tool.

There shall be a facility on the base for attaching a label indicating the address of that detector. A similar facility shall be available on the detector, enabling the fitting of a label indicating its address. When the detector is fitted to its base, both the detector and base address labels shall be visible, and aligned adjacent to each other.

39.22.3.19 Conventional / Addressable Optical Smoke Detectors

Optical smoke sensors must comply with standard EN 54.

Optical smoke sensors shall be suitable for detecting invisible products of combustion as well as visible smoke and be of the dual chamber source type to provide good stability in changing environmental conditions.

The detector shall be capable of operating within the following environmental limits:

Description	Value
Temperature operating range	–20°C to +60°C
Humidity operating range	0% to 95% RH (excluding condensation)
Wind	Up to 10 m/s

(a) Key features

- Optical technology - responds quickly to slow smouldering fires;
- CE marked;
- Designed for use with the Firewatch single and two loop fire alarm panels;
- Self- extinguishing white polycarbonate case;
- Unaffected by wind or atmospheric pressure;
- Supply voltage: 17 to 28 Volts dc;
- Operating temperature: -20°C to +60°C; and
- IP23D rating.

(b) Approvals / Certifications

- Certified to EN54 – 7 by the LPCB; and
- Loss Prevention Certification Board (LPCB) and VdS approved.

39.22.3.20 External Power Supply Unit

The external power supplies to all Aspirating detectors as well as gas release status panels shall be 24V DC and shall at least have the following functions:

- Overload protection; and
- LED indication:
  - Mains on
  - Charger on
  - Outputs ok

39.22.3.21 Open-Area Smoke Imaging Detection (OSID)

(a) General

The OSID shall be installed for the protection of the pumping room areas in each of the pumping facilities.

The system shall actively constantly measure the attenuation in these areas and be able to distinguish between real smoke particles, intruding objects (e.g. obstructions, insects), and non-smoke particles (e.g. dust).

The detector shall consist of at least two beams with different wavelengths. The system shall have high alignment tolerances that enable it to compensate for natural shifts in the building structure and be easily installed and maintained. Both the emitter and imager shall be hardwired and connected to external power supplies.

(b) Approvals

The OSID must be of a type submitted to, tested, approved, and/or listed by a Nationally Recognized Testing Laboratory (NRTL) as follows:

- CPD;
- VdS;
- UL (Underwriters Laboratories Inc), USA;
- ULC (Underwriters Laboratories Canada), Canada;
- FM (Factory Mutual);
- ActivFire, Australia; and
- AFNOR, France.

(c) Codes, Standards and Regulations

The OSID shall be installed to comply with codes and standards for beam detectors such as:

- AS 1670.1, AUS;
- BS5839.1, UKNFPA72, US; and
- GB50166, China

(d) System Description

The system shall consist of two components namely, a receiving (Imager) and emitting (Emitters) for installation along the perimeter of the protected space.

It shall use advanced dual wavelength imaging principles, ultraviolet (UV) and infrared (IR) to determine the smoke obscuration at known locations, while providing a high resistance to false alarms and obstructions.

Intruding objects that sufficiently reduce the ability of the system to measure smoke obscuration will be identified as a Trouble (Fault) or Fault alarm.

(e) The Imager

The system shall be primarily configured through DIP switches located on the Imager that allow for a number of settings to provide the best possible parameters for the particular site in which it will be installed.

The parameters will be least:

- 3 sensitivity settings for fire alarm threshold;
- Selection for particle size discrimination (dust rejection on or off); and
- Alarm latching or non-latching.

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Various Imagers shall be available covering different horizontal viewing angles.

There shall be at least Imagers for 7°, 38° and 80°, depending on the site requirements of the area to be protected.

The vertical viewing angle shall be at least 50% of the horizontal one.

Depending on the angles chosen, the respectively covered distances will vary from 150 to 34 m. For the 38° and 80° viewing angles, the system will allow a configuration of 1 up to 7 Emitters on a single Imager so the system designer can project the most cost-effective yet complying area coverage.

This set-up shall allow installing Emitters on different heights and as such providing an optimum 3D coverage of the area.

The Imager shall be powered from an external power supply at a nominal value of 24 VDC

(f) The Emitters

The Emitters must be powered from an external power supply at a nominal value of 24 VDC.

The system designer shall have a choice between Emitters with two intensities, for long range or short-range coverage.

The Emitters shall activate automatically once aligned and their position fixed and secured.

(g) System Design

The design of the system, including all spacing and mounting locations of components, shall fulfil all protection goals and local requirements. Optical filters shall be available from acceptable manufacturers that enable a calibrated test to be performed.

39.22.3.22 Commissioning and Acceptance of Gas Suppression System

(a) General

The completed system shall be reviewed and tested by a competent person to meet the approval of the Engineer. Only Plant and devices designed to national standards shall be used in the systems. To determine that the system has been properly installed and will function as specified, the tests as determined in this specification shall be completed.

(b) Enclosure Check

The protected enclosure shall be tested/inspected for general conformance with the plans and requirements of SANS 14520 Code of Practice.

(c) Review of Mechanical Components

The piping distribution system shall be inspected to determine that it is in compliance with the design and installation documents.

Nozzles and pipe size and, if appropriate, pressure – reducing devices, shall be in accordance with system drawings. The means for pipe size reduction and attitudes of tees shall be checked for conformance to the design.

Piping joints, discharge nozzles and piping supports shall be securely fastened to prevent unacceptable vertical or lateral movement during discharge. Discharge nozzles shall be installed in such a manner that piping cannot become detached during discharge.

During assembly, the piping distribution system shall be inspected internally to detect the possibility of any oil or particulate matter which could soil the hazard area or affect the extinguishant distribution due to a reduction in the effective nozzle orifice area.

The discharge nozzles shall be oriented in such a manner that optimum extinguishant dispersal can be effected.

If nozzles deflectors are installed, they shall be positioned to obtain the maximum benefit.

The discharge nozzles, piping, and mounting brackets shall be installed in such a manner that they will not potentially cause injury to personnel. Extinguishant shall not directly impinge on areas where personnel may be found in the normal work area, or on any loose objects or shelves, cabinet tops, or similar surfaces where loos objects could be present and become missiles.

All extinguishant storage containers shall be properly located in accordance with ‘approved for construction’ set of system drawings.

All containers and mounting brackets shall be securely fastened in accordance with the manufacturer's requirements.

A discharge test for extinguishants is generally not recommended. However, if a discharge test is to be conducted, the mass of extinguishant shall be determined by weighing or other approved methods. Concentration measurements should be made at a minimum of three points, one at the highest hazard level.

Other assessment methods may normally be used to reduce unnecessary discharge into the environment, for example, the door fan pressurization test specified in annex E. However, a discharge test may be conducted if acceptable to the authority.

An adequate quantity of extinguishant to produce the desired specified concentration shall be provided. The actual enclosure volumes shall be checked against those indicated on the system drawings to ensure the proper quantity of extinguishant. Fan rundown and damper closure time shall be taken into consideration.

Unless the total piping contains not more than one change in direction fitting between the storage container and the discharge nozzle, and unless all piping has been physically checked for tightness, the following tests shall be carried out.

- All open-ended piping shall be pneumatically tested in a closed circuit for a period of 10 min at 3 bar. At the end of 10 min, the pressure drop shall not exceed 20% of the test pressure; and
- All closed-section pipework shall be hydrostatically tested to a minimum of 1.5 times the maximum working pressure for 2 min during which there shall be no leakage. On completion of the test, the pipework shall be purged to remove moisture.

It is recommended that hydrostatic testing be carried out at the manufacturer's work where practicable.

Pneumatic pressure testing creates a potential risk of injury to personnel in the area, as a result of airborne projectiles if rupture of the piping system occurs. Prior to conducting the pneumatic pressure test, the protected area shall be evacuated and appropriate safeguards shall be provided for test personnel.

A test using nitrogen, or a suitable alternative, shall be performed on the piping network to verify that flow is continuous and that the piping and nozzles are unobstructed.

(d) Review of Enclosure Integrity

It is important that an effective extinguishant concentration not only be achieved, but is maintained for a sufficient period of time to allow effective emergency action. This is equally important in all classes of fires since a persistent ignition source (e.g. an arc, heat source, oxyacetylene torch, or "deep-seated" fire) can lead to resurgence of the initial event once the extinguishant has dissipated.

It is essential to determine the likely period during which the extinguishing concentration will be maintained within the protected enclosure. This is known as the hold time. The predicted hold time shall be determined by the door fan test specified, or full discharge test based on the following criteria:

- At the start of the hold time, the concentration throughout the enclosure shall be the design concentration;

- At the end of the hold time, the extinguishant concentration throughout the enclosure shall be the design concentration; and
- The hold time shall be not less than 10 minutes, unless otherwise specified by the authority.

A written report shall be prepared on completion of the test containing the following information:

a) The enclosure leak flow characteristics.

b) The design concentration of extinguishant.

c) The gross volume of the enclosure.

d) The quantity of extinguishant provided.

e) The height of the enclosure.

f) The height of the highest hazard.

g) The predicted minimum hold time and whether or not the value complies with the Code i.e. whether it is less than 10 min or the higher necessary value, as appropriate.

h) The sketch plan used in the evaluation of the enclosure.

i) The current calibration data for the fan unit and the pressure-measuring devices, and if available, corresponding certificates.

j) The test results, including a record of the test measurements and any appropriate computer printout.

k) At the start of the hold time, the concentration throughout the enclosure shall be the design concentration.

l) At the end of the hold time, the extinguishant concentration throughout the enclosure shall be the design concentration.

m) The hold time shall be not less than 10 minutes, unless otherwise specified by the authority.

(e) Review of Electrical Components

All wiring systems shall be properly installed in compliance with the appropriate national standard and the system drawings. AC and DC wiring shall not be combined in a comm. Conduit unless property shielded and grounded.

All field circuitry shall be tested for ground fault and short circuit condition. When testing field circuitry, all electronic components (such as smoke and flame detectors or special electronic Plant for other detectors, or their mounting bases) shall be removed and jumpers properly installed to prevent the possibility of damage within these devices. Replace components after testing the circuits.

Adequate and reliable primary standby sources of energy shall be used to provide for operation of the detection, signalling, control and actuation requirements of the system.

All auxiliary functions (such as alarm sounding or displaying devices, remote annunciators, air handling shutdown, power shutdown, etc.) shall be checked for proper operation in accordance with system requirements and design specifications.

Alarm devices shall be installed so that they are audible and visible under normal operating and environmental conditions.

Where possible, all air-handling and power cut-off controls should be of the type that once interrupted require manual restart to restore power.
Check that for systems using alarm silencing, this function does not affect other auxiliary functions such as air handling or power cut-off where they are required in the design specification.

Check the detection devices to ensure that the types and locations are as specified in the system drawings and are in accordance with the manufacturer's requirements.

Check the manual release devices are properly installed, and are readily accessible, accurately identified and properly protected to prevent damage.

Check that all manual released devices used to release extinguishants require two separate and distinct actions for operation. They shall be properly identified. Particular care shall be taken where manual release devices for more than one system are in close proximity and could be confused or the wrong system actuated. Manual release devices in this instanced shall be clearly identified as to which hazard enclosure they protect.

Check that for systems with a main / reserve capability, the main / reserve switch is properly installed, readily accessible and clearly identified.

Check that for systems using hold switches requiring constant manual force, these are properly installed, readily accessible within the hazard area and clearly identified.
Check that the control panel is properly installed and readily accessible.

(f) Preliminary Functional Test

Where a system is connected to a remote central alarm station, notify the station that the fire system test is to be conducted and that an emergency response by the fire department or alarm station personnel is not required. Notify all concerned personnel at the end-user's facility that a test is to be conducted and instruct them as to the sequence of operation.

Disable or remove each extinguishant storage container release mechanism and selector valves, where fitted, so that activation of the release circuit will not release extinguishant. Reconnect the release circuit with a functional device in lieu of each extinguishant storage container release mechanism.

For electrically actuated release mechanisms, these devices may include suitable lamps, flash bulbs or circuit breakers. Pneumatically actuated release mechanisms may include pressure gauges. Refer to the manufacturer's recommendations in all cases.

Check each resettable detector for proper response.

Check that polarity has been observed on all polarized alarm devices and auxiliary relays.

Check that all required end-of-line devices have been installed.

Check all supervised circuits for correct fault response.

(g) System Functional Operation Test

Operate the detection initiating circuit(s). All alarm functions shall occur according to the design specification.

Operate the necessary circuit to initiate a second alarm circuit if present. Verify that all second alarm functions occur according to design specifications.

Operate the manual release device. Verify that manual release functions occur according to design specifications.

Where appropriate, operate the hold switch. Verify that functions occur according to the design specifications. Confirm that visual and audible supervisory signals are received at the control panel.

Check the functional all resettable valves and activators, unless testing the valve will release extinguishant.

“One-Shot” valves, such as those incorporating frangible discs, should not be tested.

Check pneumatic Plant, where fitted, for integrity to ensure proper operation.

(h) Remote Monitoring Operations (If Applicable)

Disconnect the primary power supply, then operate one of each type of input device while on standby power. Verify that an alarm signal is received at the remote panel after the device is operated. Reconnect the primary power supply.

Operate each type of alarm condition and verify receipt of fault condition at the remote station.

(i) Control Panel Primary Power Source

Verify that the control panel is connected to a dedicated unswitched circuit and is labelled properly. This panel shall be readily accessible but access shall be restricted to authorized personnel only.

Test a primary power failure in accordance with the manufacturer’s specification, with the system fully operated on standby power.

(j) Completion of Functional Test

When all functional tests are completed, reconnect each storage container so that activation of the release circuit will release the extinguishant. Return the system to its fully operational design condition. Notify the central alarm station and all concerned personnel at the end-user’s facility that the fire system test is complete, and that the system has been returned to full-service condition by following the procedures specified in the manufacturer’s specifications.

39.22.3.23 Completion Certificate and Documentation

The installer shall provide to the user a completion certificate, a complete set of instructions, calculations and drawings showing the system as-installed, and a statement that the system complies with all the appropriate requirements of this part of ISO 14520, and giving details of any departure from appropriate recommendations. The certificate shall give the design concentrations and, if carried out, reports of any additional test including the door fan test.

(a) Fire Protection by Contractor

The following fire protection measures will be provided by the Contractor:

- Hand-held fire Plant; and
- Passive fire protection measures including emergency escape provision, statutory emergency signage, etc.

(b) Classification of System

The fire alarm system shall comply with the requirements as defined by SANS 10139 Code of Practice and SANS 14520.

39.22.4 Fire Water System

The Employer requirements for this sub system is contained in Annexure 39/1. The reason for this is that it involves a large mechanical input that can be easier integrated using a modular approach.

39.22.5 Smoke Ventilation

39.22.5.1 General

The Contract Works to be carried out consists of the engineering, manufacturing, supply, delivery, offloading, erection, testing and commissioning into service and maintenance of a fully function smoke control / ventilation system as described in the document and as shown on the drawings.

The engineering, quality control and inspections, Plant selection, preparation of shop drawings, testing, balancing, commissioning and preparation of operating and maintenance manuals, are to be executed in a systematic manner.

No Plant shall be installed until the Plant selection submission has been approved by the Engineer.

Samples are any samples required the Engineer. Samples shall be physical examples to illustrate materials, Plant or workmanship, and to establish standards by which the works may be judged. Such samples, after approval, will be retained by the Architect or Engineer for a period sufficient to ascertain that the relevant component is actually provided as per such sample, but will then be returned to the Contractor for incorporation in the works.

Prior to the carrying out of acceptance tests the Contractor shall operate the entire system for as long a period as may be required to provide satisfactory performance in this specification and SABS 0287 Code of Practice at all times for 24 hours a day continually.

39.22.5.2 Electro-Mechanically Controlled Smoke Ventilators

(a) General

The ventilators are to be fitted with power to open / power to close 24V DC rack actuator and a 72ºC fusible link. Each ventilator is to incorporate an overriding fusible link opening mechanism.

The controls to be provided shall be such as to automatically operate the smoke ventilation Plant when required for smoke ventilation, relief air inlet, natural day-to-day ventilation, and testing or maintenance purposes.

(b) Smoke Ventilators

The units shall be clear opening, fully controllable multi-louvered ventilators. Louvre blades are to be aluminium with the ventilator having welded galvanized steel bases and bodies. The intension is that the ventilators fit in between the purloins.

The units are to be of the spring open (failsafe) type and must be provided with linkages, actuators, springs, etc. and factory assembled and tested to provide electric activation to close, with a soldered fusible link thermal override. All pivots shall run on UV stabilized nylon bearings.

The controls are to be located on the inside of the ventilator i.e. inside the ventilator throat and must operate the louvres via a control arm.

Once installed the flashings required to provide a weather-tight, leak free installation shall be supplied and installed by the roof sheeting contractor. Co-ordination between the smoke ventilation system contractor and the roof sheeting contractor will be required to ensure that the best flashing detail / system is determined for the project. Flashing details are to be submitted for approval to the fire consultant prior to any roof ventilators being installed on Site. All back flashing necessary to successfully complete the installation shall be supplied and installed by smoke ventilation contractor.

The smoke ventilators are to be suitable for the wind loading to which they will be subjected, i.e. wind shall not affect either the operation or integrity of the units.

The ventilators shall comply with European Standard EN 12101 Part 2.

The ventilators shall be provided with 72 hour battery back-up as per EN 12101-10.

The base is to be assembled from welded sections of galvanised steel. This structure provides the means with which the ventilator can be attached to the frame. It also offers a means to weather the fixing, drain off rainwater and affix the remaining constituent parts. No rivets are to be used in the construction of the ventilator base.

The louvre blades are to be manufactured from mill finish aluminium. When in operation, the louvres are to serve to regulate the flow of air passing through the ventilator and prevent the entry of water when closed.

The louvre pivots comprise three-piece parts:

- The pivot pin in aluminium to BS 1474;
- The outer bush in ultra violet light stabilized nylon; and
- The inner bush in ultra violet light stabilized nylon.

The louvre pivots are an axis around which the louvres must rotate and by virtue of the double nylon bushes must require no lubrication.

The fusible link must be is of the soldered type and must be rated and tested at 72°C. If the link is subjected to abnormally high temperatures, caused by a fire in the vicinity, it must respond by parting overriding the conventional controls allowing the ventilator to open.

Fusible link shields are to be installed around the fusible links. The fusible link shields are to be manufactured in aluminium to BS 1470 1972 NS4 H3 Grade 0 by pressing or spinning.

The ventilators are to be dispatched fully assembled to site. No Site work on the ventilators will be permitted.

The ventilators must have successfully completed an accelerated life cycle test of 30 000 operating cycles in accordance with EN 12101 : Part 2.

The ventilators should be fully supported. If the sizes of the ventilators does not conform with the purlin spacing an H-frame shall be provided and included in the design and price submitted.

The materials used in the construction of the ventilator must have qualities suitable for its performance as a fire ventilator. The grade of aluminium used must be such that it will not deform or buckle at elevated temperatures, thereby maintaining the ventilators integrity. If temperatures exceed the materials melting point, anticipated to be approximately 580 - 650°C the ventilator blades will take on a plastic consistency before disintegrating rapidly, to leave the vent throat unobstructed.

The ventilators are to be structurally unaffected by the presence of water or moisture and must fully weathered when the louvers are closed.

The ventilators must have passed Wind & Rain tests EN 12101 : Part 2 Clause 5,3. This test requires that the ventilators withstand 75mm per hour with 13m/s wind.

A full test programme must have been undertaken on the proposed ventilators in accordance with EN 12101: Part 2 and all the relevant requirements of that Standard must have been satisfied.

These requirements include, but not limited to:

- Co-efficient of performance has been measured, with side wind applied;
- Slow temperature rise test successfully completed;
- Fast temperature rise test successfully completed;
- 30 000 life cycle test successfully completed;
- Fire and heat tests successfully completed;
- Rain and wind tests successfully completed;
- Wind load tests for suction and pressure completed;
- Side wind load tests successfully completed; and
- Operating time test successfully completed. Each ventilator needs to be fully opened within 60 seconds.

Performance details relating to the coefficients of ventilators proposed must be submitted to the Engineer, and these coefficients must be the ones determined with full fittings (i.e. controllers, burglar etc.) in place.

Where ventilator design is such that blades in the open position protrude above the body of the ventilator, wind shields must be provided.

(c) Electric Actuator

Each ventilator is to be fitted with a Belimo 230V AC / 24V DC failsafe smoke and fire damper electric actuator. Where uninterruptible standby power is available 230V AC units can be utilized, otherwise 24V DC units must be employed, with due care being taken of voltage drop properties of extended cable lengths.

All ventilators are to be spring open, power close ensuring in the event of a power outage the ventilators will failsafe to an open position.

The following is an example of the details that are to be submitted to the Engineer:

Type	:	Louver roof ventilator by Company XXX
Number	:	12
Throat Size	:	2 000mm W x 2 000mm L
Body Size	:	2 150mm W x 2 150mm L
Ventilator Height	:	300mm
Operation System	:	Electric, failsafe incorporating BF 230V AC Belimo Actuators
Over Riding Fusible Link	:	Yes, temperature rating - 72ºC
Base Flange Type	:	To suit roof / side sheeting profile
Louver Type	:	Aluminium, twin wall
Base	:	High base, not insulated
Wind Baffle	:	Yes, standard
Throat Area	:	3.00m2
Co-efficient of Discharge	:	0.68
Aerodynamic Free Area	:	2.04 m^2

39.22.5.3 Electric Control Panels

(a) General

All smoke extract units must operate by means of a double knock fire signal from the fire alarm system.

24 V relays must be provided by the smoke ventilation contractor at the control panels. The fire alarm system sub-contractor must install the necessary wiring to the relays from the fire control panel. These signals will be required to automatically operate the required zone / zones of smoke ventilators.

The electrical contractor must provide a 220 V 1 phase, dedicated and uninterruptible power supply from a clean line source to each of the smoke ventilation system control panels. Where 3 phase supplies are required the starting method must be specified i.e. DOL or Star-Delta and all current requirements must be clearly stated.

Manual selector switches located on the front of each of the control panels must allow the ventilators to be opened for day-to-day ventilation as and when required.

The control panels must be designed built and wired in compliance with the South African Bureau of Standards wiring code SABS 0142-1, where it applies to electrical control panels, distribution boards and switchgear, as well as to the SABS 1765 regarding the safety of distribution boards.

The panels shall comply with the SABS IEC 60529 where it applies to the protection of persons, namely Standard “B” finger contact. IP ratings relating to the protection of ingress of solids or water shall be in accordance with the application of these control panels, but not less than IP54.

All of the power conducting components within the control panels shall be compliant with the SABS / IEC standards listed below:

- Isolating Switches : SABS / IEC 60947 – 3
- Circuit Breakers : SABS / IEC 60947 – 2
- Earth Leakage Circuit Dis-Connectors : SABS / IEC 61008 - 1
- Contactors : SABS / IEC 60947 – 4 - 1
- Overload Protection Relays : SABS / IEC 60947 – 4 - 1
- Terminals / Connectors : SABS / IEC 60998 – 2 - 1

The individual control panels shall contain, as a minimum, the following:

- Smoke extraction control panels for fans with power close, spring open louver motors, DOL starting; and
- The enclosures shall be manufactured to a minimum of IP55 Ingress Protection. They shall be epoxy powder coated to RAL 7032, light grey – the colour may be changed by the Engineer at a later stage. They shall be equipped with wall mounting brackets and a removable gland plate.

Mounted inside the enclosure shall be the following Plant:

- 1 x Pad-lockable off main isolator;
- 1 x Control circuit protection MCB;
- 1 x Transformer rectifier set;
- 1 x Mains monitoring relay;
- 1 x Audible alarm mute relay;
- 1 x Audible alarm mute push button;
- 1 x Alarm re-activate timer;
- 1 x Flashing relay;
- 1 x Set of terminals to provide a potential free contact for the connection of a remote alarm system;
- 1 x Fire signal monitoring relay for each fire zone;
- 1 x Louver motors MCB for each fire zone;
- 1 x Louver contactor for each fire zone;
- 1 x Louver re-close delay timer for each fire zone;
- 1 x Louver maintenance isolator for each fire zone;
- 1 x Set of motor protection fuses for each fan;
- 1 x Motor switching contactor for each fan;
- 1 x Thermal overload relay for each fan;
- 1 x Overload by-pass relay for each fire zone; and
- 1 x Starting delay timer for each fan.

Mounted on the front hinged access door of the enclosure shall be the following Plant:

- 1 x Power on indicator;
- 1 x 24V DC on indicator;
- 1 x Fire incident indicator for each fire zone;
- 1 x System initiated indicator for each fire zone;
- 1 x System running indicator for each fire zone;
- 1 x System fault indicator for each fire zone;
- 1 x Overload tripped indicator for each fire zone;
- 1 x Manual / auto selector switch for each fire zone; and
- 1 x Audible alarm mute push button.

Mounted on the roof of the enclosure shall be the following Plant:

- 1 x Audible alarm; and
- 1 x Flashing beacon.

(b) Smoke Extraction Control Panels for 230 V 50 Hz Ventilators

All Control panels to be manufactured in strict accordance of EN12101. Certificate of compliance will be required.

The enclosures shall be manufactured to a minimum of IP55 Ingress Protection. They shall be epoxy powder coated to specifications and equipped with wall mounting brackets and a removable gland plate.

Mounted inside the enclosure shall be the following Plant:

- 1 x 16 Amp SP incoming supply isolator;
- 1 x 230 V 50 Hz / 24 V DC transformer rectifier set for indication and fire signal monitoring;
- 1 x Control circuit MCB;
- 1 x Mains monitor relay;
- 1 x Audible alarm mute relay;
- 1 x Flashing relay;
- 1 x Audible alarm re-start timer;
- 1 x Remote alarm condition signalling relay;
- 1 x Set of terminals for the connection of the incoming supply, the fire signals, the remote alarm;
- Signal and the ventilators;
- 1 x Fire signal monitoring relay for each fire zone;
- 1 x Ventilator contactor for each fire zone; and
- 1 x Ventilator maintenance isolator for each fire zone.

Mounted on the front hinged access door of the enclosure shall be the following Plant:

- 1 x Power on indicator;
- 1 x 24V DC on indicator;
- 1 x Ventilators open / close control switch for each fire zone;
- 1 x Fire incident indicator for each fire zone;
- 1 x Ventilators open indicator for each fire zone; and
- 1 x Control system fault indicator for each fire zone.

Mounted on the roof of the enclosure shall be the following Plant:

- 1 x Audible alarm; and
- 1 x Flashing beacon.

A signal from any of the smoke zones within a given fire compartment shall automatically activate all the smoke extract units in that smoke zone. This mode of operation shall be the norm for the building except where adjacent zones of natural type ventilators are to be activated to provide replacement air facilities. The number and location of the replacement air zones must be in accordance with the design criteria.

39.22.5.4 Electric Reticulation

(a) General

The complete smoke control / management system must be wired up and connected in a failsafe configuration.

All electric wiring reticulation shall be carried out in accordance and in compliance with the South African National Standard, SANS 10142 - 2005 Edition.

All wiring is to be drawn in steel conduit, which is to be supplied and installed in an unpainted finish.

(b) Roof Vents

For each smoke zone the electric reticulation between the control panel and the roof ventilators is to run inside the building in steel conduit until it reaches transverse roof monitor in that zone, at which point the reticulation is to be fixed to the roof steelwork and run to the roof ventilators. All cabling between the smoke ventilation system control panels and the roof ventilators shall be PH-30 wiring.

39.22.5.5 Block Diagram

A schematic block diagram, outlining each smoke zone's Plant and the operation of the installation shall be mounted on the wall next to each control panel.

The diagram shall depict the installation layout to a scale of 1:500 and include sufficient outlines and labelling to enable the function of the selector switches and controls to be easily identified.

39.22.5.6 Description of Smoke Control / Ventilation System

In brief, the installation shall consist of:

- Electrically operated, roof mounted smoke ventilators where deemed necessary. There are two sites and buildings requiring ventilators namely;
  - i) High-Lift Pumping Station;
  - ii) Low-Lift Pumping Station;
- Dedicated electric control panels (one for each warehouse); and
- Sets of suitably rated, interconnecting electric reticulation.

With regards the smoke control / ventilation system, the following is applicable:

HIGH LIFT PUMP STATION

Description	Value
Area to be ventilated	Warehouse
Measured ventilation area (A_v)	25m²
Method of actuation	Mechanically Actuated
Fusible link activation temperature	72°C

LOW LIFT PUMP STATION

Description	Value
Area to be ventilated	Warehouse
Measured ventilation area (A_v)	10m²
Method of actuation	Mechanically Actuated
Fusible link activation temperature	72°C

39.22.6 Statutory Emergency Signage

The Works to be carried out consists of the detailed design, manufacturing, supply, delivery, offloading, installation, testing and commissioning into service, and maintenance of the statutory emergency signage installation.

The engineering, quality control and inspections, Plant selection, preparation of shop drawings, testing, balancing, commissioning and preparation of operating and maintenance manuals, are to be executed in a systematic manner.

All pictograms, except the statutory signage are to comply fully with SANS 1186: Part 1.

All statutory emergency signs are required to be the photo-luminescent type tested and approved by the SABS to SANS 1186: Part 5 and shall bear the relevant mark from such testing facility.

All signs including the evacuation plans are to be framed in anodised aluminium frames approved by and the Engineer.

The Engineer reserves the right to request alternative frames prior to commencement of manufacture.

Signs shall preferably be suspended from ceilings. Only in unavoidable situations may sign be fixed to walls or other fixtures and may only be done so after approval by the Engineer.

The materials used for suspension and/or fixing of signs shall be of a non-combustible type with relevant hanging mechanisms to the Engineer's satisfaction.

Where signs are fixed to walls, this shall be done only with the use of at least four screws positioned in the corners of the sign in question.

39.23 SUBSTATION AUTOMATION

39.23.1 Architecture

The Contractor shall submit his proposed substation automation architecture to the Engineer for approval.

A typical proposed architecture is shown below (Figure 39/1), but Contractors may submit variations to this architecture for approval by the Engineer.

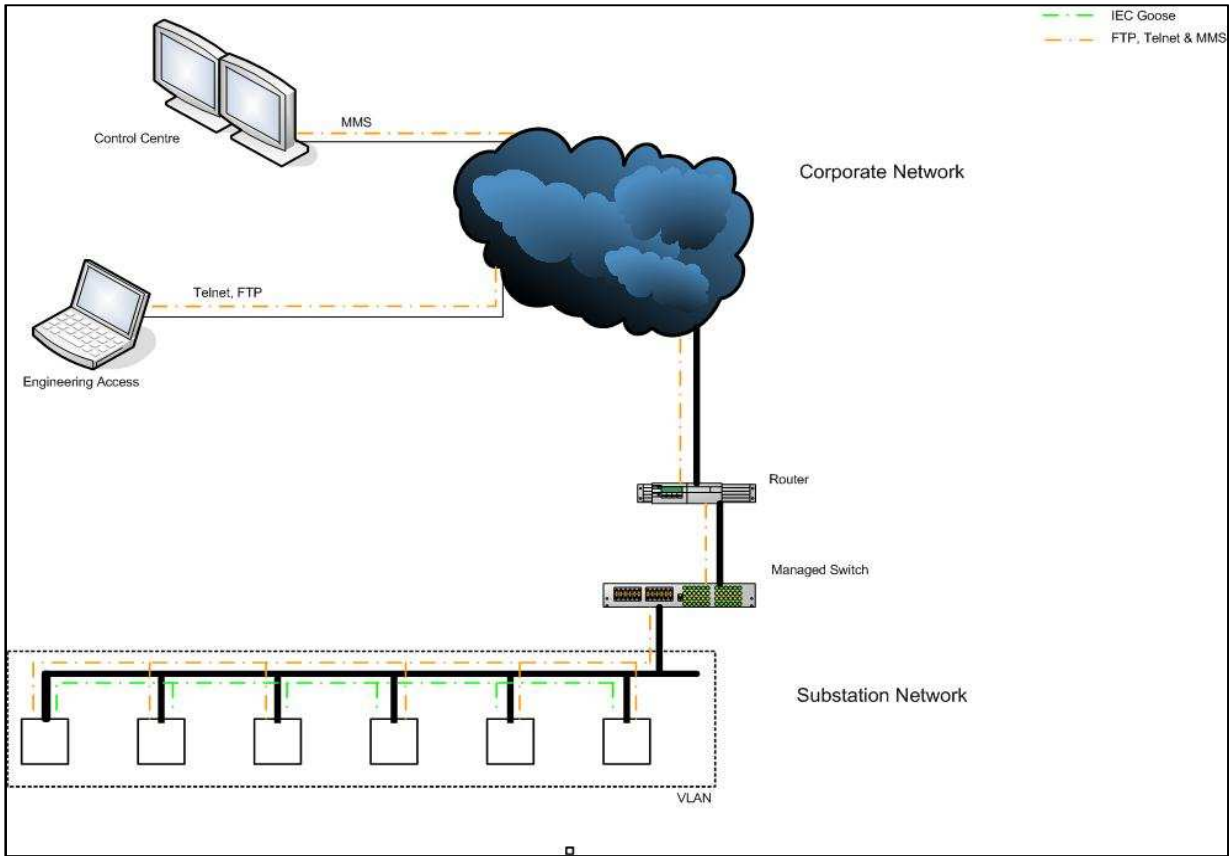

FIGURE 39/1
PROPOSED AUTOMATION ARCHITECTURE

39.23.2 Protocol

The substation must be IEC 61850 compliant with the following minimum requirements:

a) Devices should have redundant ethernet connections that are capable of failing over and using IEC 61850 MMS and IEC 61850 GOOSE on both ports;

a) Subscription to multiple GOOSE messages from multiple devices should be allowed;

b) GOOSE configuration must allow network settings such as priority and VLAN settings as well as other settings;

c) GOOSE reception must support VLAN and priority settings;

d) GOOSE transmit must be able to transmit all data types in the data set (not just digitals);

e) GOOSE reception must support multiple data types (not just digitals) - this is a preferred option;

f) GOOSE messaging must comply with the IEC 61850 GOOSE and not the UCA2 GOOSE i.e. flexible size of data set that is not limited as well as multiple data type support as per 4 and 5;

g) GOOSE timing must be at least equal to a hardwired interface. (Specify GOOSE timing);

h) Flexible device modelling that allows proper IEC 61850 logical node modelling. Device must allow user to select Logical Nodes that apply to the application and must not force user into a predefined model. This must be possible in the device ICD file and must not require firmware changes every time a model is changed;

i) Flexible data attribute modelling. User must be able to add new data attributes to a Logical Node as per the appendix of IEC 61850-7-4;

j) Extendible Logical Node modelling. User must be able to add new Logical Nodes as per the appendix of IEC 61850-7-4;

k) Preferably no GGIO logical nodes should exist in the network; and

l) Devices must not impose arbitrary limits on naming conventions that are not in line with the Specification.

39.24 SUBSTATION EARTHING

39.24.1 Scope

This Clause contains guidelines and standards for the supply, connection, installation and testing of all earth mats, rods and associated Plant in substations.

The Contractor shall perform earth resistance testing and submit an earthing design for approval by the Engineer.

39.24.2 Interpretation

The requirements of the following documents shall apply to the Plant covered in this Clause. In the event of any discrepancy between the requirements of these documents and this Clause, the requirement of this Clause shall prevail:

BS 162 : Electrical switching Plant and associated apparatus.

CP 1013 : Earthing.

SANS 1063	:	Earth rods, couplings and clamps.
SANS 03	:	Lightning protection - structural.
SANS 03A	:	Lightning protection - residential dwellings.

39.24.3 Material

Earth mats shall consist of round copper rods in the formation shown on the Drawings. Connection from the earth mats can be made with flat copper strap. Where fault levels necessitate, more than one connection must be made to the earth mat by means of different earth straps, to prevent an overload during fault conditions.

Plant which is earthed at various points, i.e. security fencing, can be connected with 40 x 3 mm flat copper strap to the earth mat.

39.24.4 Construction Equipment

The earth mat of a substation should be laid at a depth of 1 m. All connections and crossings should be connected with Cadweld. Where the copper conductors are connected with bolts above ground surface, they should be tinned. Connections against galvanised structures should only be done on vertical surfaces. These areas should be greased or painted to prevent corrosion.

A vertical copper earth bar of 500 mm x 60 mm x 8 mm, is to be mounted on insulators with at least 4 kV isolation, in the 11 kV cable trench inside the switching station building. This earth bar should be linked to the main earth mat with multiple 50 mm x 3 mm copper straps.

39.24.5 Installation

39.24.5.1 Armouring

All armoured cables shall be earthed at both ends.

39.24.5.2 Spare Conductors

All spare conductors in control cables should be terminated on spare terminals at the end of the cable which feeds the controlling Plant. These terminals should be short circuited and earthed so that the cable is connected to the earth on one side only.

39.24.5.3 Control Cables

All control cables with a metal foil or with separate earth conductors are to be earthed only at the end of the conductors or foil, which feeds the controlling Plant.

39.24.5.4 Fencing

Security fencing should be connected to earth mats. The earth mats should be 1 m underneath the fencing, to prevent a potential between the fencing and the surrounding surface.

39.24.5.5 Electronic Relays

Electronic relay covers should be connected to the relay panel with a straight earth conductor.

39.24.5.6 Tolerance

The maximum tension between an earth mat and true earth must be 400 V at the systems fault current.

39.24.6 Tests

All structures must be tested for a continuity of earth conductors after installation.

Acceptable techniques must be used when resistance between the earth mat and true earth is tested.

39.25 SUBSTATION PLANT

39.25.1 Scope

This Clause deals with the standard Plant, as well as the official notice boards which are to be fitted in every substation.

39.25.2 Interpretation

This Clause describes the requirements for Plant in substations which shall also conform to the requirements of the Occupational Health and Safety Act no. 85 of 1983 and its regulations.

39.25.3 Construction Equipment

39.25.3.1 Switch Room

A fire extinguisher shall be fitted in each substation room. Each fire extinguisher shall have a capacity of at least 2.72 kg and must be equipped with a long distance spray nozzle suitable for use on electrical fires. The fire extinguishers shall be mounted (tightly secured) near the door on a red painted wall or wall with a red background.

39.25.3.2 Danger Signboards / Notice Boards

The switch room shall be provided with three signboards with the words “DANGER - DO NOT SWITCH ON”. The size of the signboards shall be 152.4 x 152.4 mm and shall be made out of 6.35 mm thick tempered glass fibre. The letter size of the word “DANGER” shall be approximately 12.55 mm. The letters shall be red or black on a white background.

39.25.3.3 Labels

All Plant, where applicable, shall be provided with appropriate name plates with lettering of approximately 6 mm. Letters shall be engraved on name plates. Embroidered PVC tape will not be accepted.

39.25.3.4 Storage Cabinet for Plant

Fuses and all accessories for operating Plant shall be stored in a cabinet against a wall. The cabinet shall be fitted with doors and catches.

If the cabinet is manufactured of wood, the cabinet shall be treated, inside and outside with two coats of high gloss varnish.

39.25.3.5 Switch Yard

Circuit designation labels must be provided at all line terminations, isolators, circuit breakers and transformers as described on the Drawings.

Labels shall be manufactured from aluminium with 50 mm lettering, covered with an epoxy resin material. Supports must be provided as necessary.

39.25.4 Installation

39.25.4.1 Internal Signs

All official notices must be fitted in a suitable place on the wall in each substation room.

The following notices of an appropriate size, with black or red words and illustrations on white plastic sheet (filon board) are required. The choice of language shall depend on the region in which the project is executed.

A:	Warning:	Unauthorised handling of machinery and electrical apparatus prohibited.

B: A notice with the complete instructions of how to react in the case of fire, in each of the following languages:

English

Afrikaans

Zulu

Xhosa

C: A notice with complete instructions regarding the procedures for first aid in the case of electrical shock, in each of the following languages:

English

Afrikaans

Zulu

Xhosa

39.25.4.2 External Signs

The following notices must be screwed to the outside of each substation building:

a) A triangular warning sign with a black lightning fork on a yellow background with black outline. The warning sign shall comply with the SANS standard 1186 WWF Size 290 x 290 mm.

b) A notice which prohibits unauthorised entry, using the following words:

- Danger : Unauthorised entry prohibited.

c) The name of the substation on white plastic (Filon) board using 50 mm letters.

d) A notice with all the telephone numbers in case of an emergency.

39.25.5 Tolerance

Not applicable.

39.25.6 Tests

Not applicable.

39.26 WORKS, TESTS AND INSPECTION

All Plant shall be fully tested in the Contractor's workshops before despatch to Site. Provision shall be made for the necessary Plant for a complete test. The Engineer shall be invited to witness such tests and to inspect the Plant before despatch. The Contractor shall give the Engineer written notice of Plant being ready for test and shall not commence testing without confirmation from the Engineer.

All costs and charges for the tests and inspection shall be included in the prices for the respective items.

39.26.1 Site Tests and Inspection

39.26.1.1 Field Installation Check Lists (FICLs)

The Contractor shall complete field installation check lists (FICL) for each individual portion of the installation, progressively. The FICLs shall include visual inspection notes and tests results, which shall be signed by the Engineer’s assistant on Site. Progress payments will be made based on the FICLs.

39.26.1.2 Tests and Tests on Completion

The complete FICLs, testing and Tests on Completion of the electrical Plant and systems shall be in accordance with the following procedure:

a) Before primary and secondary connections are made to the transformer, megger primary-to-tank, secondary-to-tank and primary-to-secondary;

b) Megger all outgoing circuits to earth and for electrical continuity;

c) Tighten all accessible bolts on circuit breakers, isolators, etc.;

d) Check that phasing of all new Plant corresponds to that of the existing system;

e) Switch on main incoming circuit breaker with all outgoing circuit breakers open;

f) Switch on each circuit and check for correct operation of the circuit, and that the circuit breaker is suitably rated for current drawn;

g) Check all control circuits (motor, interlock remote, auto-transfer, auto-restart, etc.) for correct operation; and

h) Loop test all I/O circuits to the PLC, before functional testing of the software and programming.

39.27 MEASUREMENTS AND PAYMENT

The rates tendered under this Section shall not include for the general obligations, Contractor's Plant and work deemed to be covered by the items provided in, Section 1 – General.

39.001 Design and documentation — Unit: lump sum (Sum)

The rates tendered shall include for full compensation of all costs incurred in the preparation of the design and calculations, detail working drawings for all items, specifications, schematic diagrams, electrical drawings and wiring diagrams, layout drawings, operation and maintenance instructions, programmes of work (manufacture and on-Site) and any other work as specified for the design of the complete installation. Payment will only be effected after the design and associated documentation has been approved by the Engineer.

Measurement and Payment for the preparation and submission of O&M Manuals shall be covered under Clause 48.11 of Section 48 – Tests on Completion and paid elsewhere.

39.002 Supply and deliver to Site

Unit: number (No)
or: sets (Sets)
or: pairs (Pairs)
or: lump sum (Sum)
or: length (m)

The rates tendered shall include full compensation for the supply and delivery of the Plant to Site including supply of raw materials and bought-out items and associated operating Plant items (i.e. gearboxes and actuators; limit switches; cabling and electrical panels); fabrication, manufacture and assembly; quality assurance and quality control; inspection and Factory Acceptance Testing (including attendance on inspections and tests witnessed by the Engineer); type and routine tests; application of finishes (painting and corrosion protection); trial erection and dismantling; preparation and packing for transport; transport from place of manufacture to the Site; insurance, harbour dues etc., during transport; loading and unloading; storage under appropriate conditions from date of delivery until commencement of erection; and any other work as specified. Payment will be made per unit. Payment will only be effected after full compliance of the Plant items with this Section and associated documentation has been approved by the Engineer.

a) Electric cables — Unit: length (m)

Cable lengths are approximate lengths. Installed cable will be measured on Site.

Rates shall include for all clamping, strapping and cable tag marking. Trenching is priced separately.

b) Cable terminations and joints **Unit: number (No)**

The rates for cable terminations and joints shall include for cable glands / termination kits, shrouds, crimped lugs, connection to terminals, core ferrule numbers and cable tag number inside the compartment or motor connection box.

c) Cable ladders **Unit: length (m)**
Unit: number (No)

The rate shall include for heavy duty cable ladders, complete with bends, elbows, tee-pieces, unistrut mountings, fixings and splices.

d) Conduit **Unit: length (m)**

The rate shall include for all draw boxes, elbows, bends and fixing material.

e) Luminaries **Unit: number (No)**

The rate shall include for all lamps, control gear and support brackets.

f) MV and LV switchboards and MCC **Unit: number (No)**

The rates shall include all relays and control Plant as shown on Drawings and as specified and all mounting Plant.

g) MV Variable Speed Drives **Unit: number (No)**

The rates shall include all relays and control Plant as shown on Drawings and as specified and all mounting Plant. Drive systems shall be complete with all transformers, filters etc., to complete the installation.

h) Cable trenches **Unit: length (m)**

The rates shall include full compensation for excavation, top and bottom layer of soft sifted soil, cable marker tape and backfill as specified.

i) Substation safety Plant **Unit: lump sum (Sum)**

The rates shall include full compensation for all safety Plant and warning signs as per OHS ACT, including fire extinguishers, notice boards and padlocks.

j) Standby generator set **Unit: number (No)**

The rates shall include a standby generator set complete with control panel, protection relays and all fuel tanks specified and all mounting Plant. The generator shall be handed over with full tanks of fuel.

k) Transformers and NER **Unit: number (No)**

The rates shall include transformers and NERs complete with protection relays and sensors, transformer oil and all mounting Plant.

l) Miniature substations **Unit: number (No)**

The rates shall include miniature substations complete with ring main units, circuit breakers, switch disconnectors, transformers, busbars, protection relays and sensors, transformer oil and all mounting Plant.

m) Bulk metering kiosk **Unit: number (No)**

The rates shall include bulk metering kiosks complete with ring main units, circuit breakers, switch disconnectors, busbars, protection relays and sensors, and all mounting Plant.

n) Earthing and lightning protection **Unit: number (No)**
Unit: length (m)
Unit: lump sum (Sum)

The rates shall include full compensation for an earthing and lightning protection system complete with all conductors, earth rods, isolators, bolts, nuts, welding, copper, trenching and other usable materials to complete the installation, true earth conductivity and earth mat resistance tests.

o) Uninterruptible power supply(UPS) **Unit: number (No)**

The rates shall all relays, control and batteries as shown on Drawings and as specified and all mounting Plant.

p) Batteries and battery chargers **Unit: number (No)**

The rates shall include all relays, control, cubicles and batteries as shown on Drawings and as specified and all mounting Plant.

q) Power factor correction **Unit: number (No)**

The rates shall include all relays, control and cubicles as shown on Drawings and as specified and all mounting Plant.

r) Fire protection system **Unit: lump sum (Sum)**

The rates shall include all relays, control, sensors, cabling, gas suppression system, panels and all mounting Plant as required.

s) MV Motor surge protection **Unit: number (No)**

The rates shall include all Plant and cubicles and all mounting Plant.

t) Motors for Pumps **Unit: number (No)**

The rates shall include the design, manufacture, inspection, factory testing, packaging and delivery of all Plant as specified.

39.003 Installation of Plant **Unit: number (No)**
or: sets (Sets)
or: pairs (Pairs)
or: lump sum (Sum)
or: length (m)

The rates tendered shall include for full compensation for the installation of the Plant on Site including the provision of all labour, transport, materials and Temporary Works necessary to install the complete Works; on-Site quality assurance and quality control, inspection, testing (including attendance at tests witnessed by the Engineer); the installation of all auxiliary Plant items, actuators, limit switches, electrical panels, cabling etc.; necessary for the operation of the installation until taken over by the Employer; the putting into service of the complete installation of the Plant; and any other work as specified.

The rate shall also include for all pre-commissioning testing and the provision of Plant therefore including all disruptions to installation caused by such testing. Payment will be made per unit. Payment will only be effected after full compliance of the Plant items with this Section and associated documentation has been approved by the Engineer.

Measurement and Payment for Test on Completion shall be covered under Clause 48.11 of Section 48 – Tests on Completion and paid elsewhere.

a) Electric cables **Unit: length (m)**

Cable lengths are approximate lengths. Installed cable will be measured on Site.

Rates shall include for all clamping, strapping and cable tag marking. Trenching is priced separately.

b) Cable terminations and joints **Unit: number (No)**

The rates for cable terminations and joints shall include for cable glands / termination kits, shrouds, crimped lugs, connection to terminals, core ferrule numbers and cable tag number inside the compartment or motor connection box.

c) Cable ladders **Unit: length (m)**
Unit: number (No)

The rate shall include for heavy duty cable ladders, complete with bends, elbows, tee-pieces, unistrut mountings, fixings and splices.

d) Conduit **Unit: length (m)**

The rate shall include for all draw boxes, elbows, bends and fixing material.

e) Luminaries **Unit: number (No)**

The rate shall include for all lamps, control gear and support brackets.

f) MV and LV switchboards and MCC **Unit: number (No)**

The rates shall include all relays and control Plant as shown on Drawings and as specified and all mounting Plant.

g) MV Variable Speed Drives **Unit: number (No)**

The rates shall include all relays and control Plant as shown on Drawings and as specified and all mounting Plant. Drive systems shall be complete with all transformers, filters etc., to complete the installation.

h) Cable trenches **Unit: length (m)**

The rates shall include full compensation for excavation, top and bottom layer of soft sifted soil, cable marker tape and backfill as specified.

i) Substation safety Plant **Unit: lump sum (Sum)**

The rates shall include full compensation for all safety Plant and warning signs as per OHS ACT, including fire extinguishers, notice boards and padlocks.

j) Standby generator set **Unit: number (No)**

The rates shall include a standby generator set complete with control panel, protection relays and all fuel tanks specified and all mounting Plant. The generator shall be handed over with full tanks of fuel.

k) Transformers and NER **Unit: number (No)**

The rates shall include transformers and NERs complete with protection relays and sensors, transformer oil and all mounting Plant.

l) Miniature substations **Unit: number (No)**

The rates shall include miniature substations complete with ring main units, circuit breakers, switch disconnectors, transformers, busbars, protection relays and sensors, transformer oil and all mounting Plant.

m) Bulk metering kiosk **Unit: number (No)**

The rates shall include bulk metering kiosks complete with ring main units, circuit breakers, switch disconnectors, busbars, protection relays and sensors, and all mounting Plant.

n) Earthing and lightning protection **Unit: number (No)**
Unit: length (m)
Unit: lump sum (Sum)

The rates shall include full compensation for an earthing and lightning protection system complete with all conductors, earth rods, isolators, bolts, nuts, welding, copper, trenching and other usable materials to complete the installation, true earth conductivity and earth mat resistance tests.

o) Uninterruptible power supply (UPS) **Unit: number (No)**

The rates shall all relays, control and batteries as shown on Drawings and as specified and all mounting Plant.

p) Batteries and battery chargers **Unit: number (No)**

The rates shall include all relays, control, cubicles and batteries as shown on Drawings and as specified and all mounting Plant.

q) Power factor correction **Unit: number (No)**

The rates shall include all relays, control and cubicles as shown on Drawings and as specified and all mounting Plant.

r) Fire protection system **Unit: lump sum (Sum)**

The rates shall all include all relays, control, sensors, cabling, gas suppression system, panels and all mounting Plant as required.

s) MV Motor surge protection **Unit: number (No)**

The rates shall include all Plant and cubicles and all mounting Plant.

t) Motors for Pumps **Unit: number (No)**

The rates shall include the installation, on-Site inspection, testing and pre-commissioning of all Plant as specified.

39.004 Spares — Unit: Provisional sum (PS)

The cost of spares delivered to Site and handed over will be paid as a lump sum.

The actual lump sum to be paid shall be based on the unit rates priced in the BoQ for the actual spares ordered and supplied and the Employer is entitled to purchase all, some or none of the items listed.

The rate tendered shall provide for the manufacture, supply, delivery to Site and handing over of the spares ordered and shall include permanent packing for long term storage. The spares shall be manufactured at the same time as the installed items.

ANNEXURE 39/1
FIRE WATER SYSTEM

A39.1 GENERAL

The Contract Works to be carried out consists of the detailed design / shop drawing preparation, engineering, manufacturing, supply, delivery, offloading, erection, testing and commissioning into service and maintenance of a pumped water supply for fire water reticulation systems.

The engineering, quality control and inspections, Plant selection, preparation of shop drawings, testing, commissioning and preparation of operating and maintenance manuals, are to be executed in a systematic manner.

All other relevant modular Specifications shall be applicable.

A39.2 PIPEWORK

A39.2.1 Above-Ground Pipework

All above ground pipework installed inside buildings up to and including 150 mm diameter shall be of Medium Grade Black Piping to SANS 62. Where above-ground pipework exceeds 150 mm diameter, this shall be of Medium Quality Black Piping to SANS 719 having a wall thickness of at least 6 mm.

A39.2.2 Pipework Below Ground

All piping below ground level smaller than 150 mm is to be of medium grade black piping to SANS 62 suitably protected against corrosion with two layers of fully overlapping Denso tape wrapping or equally approved, or Class 16 HDPE may be used for pipes always under pressure as per SANS 966 Code of Practice. Pipes in excess of 150 mm diameter shall be medium grade quality black piping to SANS 719 with two layers of fully overlapping Denso tape wrapping or equally approved or HDPE piping to SANS 966 as above.

A39.2.3 Non-Return Valves

A reflux / non-return valve shall be fitted to the water supply connection with testing arrangement.

Non-return valves suitable for this application shall be installed at the following positions:

- On each water supply from a main;
- On a booster pump connection;
- Between a pump connection and the communication pipe that serves the installation; and
- On any pipe that is provided with a booster pump connection and that is connected to a storage tank in such a position and way as to prevent the flow of water into the tank when the pump connection is in operation.

A39.2.4 Pressure Gauges

Glycerine-filled pressure gauges fitted to this type of installations shall be suitable for sprinkler use and shall conform to BS 1780. The maximum scale value shall be approximately 150% of site maximum pressure. Scales shall have divisions not exceeding 0.20 Bar. Pressure gauges shall be installed with gauge cocks to enable each pressure gauge to be readily removed without interrupting the system water supply.

The Contractor shall ensure that all permanently installed instrumentation necessary for monitoring of status and performance of the system shall be of such dimensions and mounted in position so that they are easily and accurately readable by an operator standing on the floor.

A39.3 PUMPING SYSTEMS

A39.3.1 General

A block plan of the system with the position of the main site connections and fire hydrants clearly indicated thereon shall be fitted in the pump chamber.

The block plan shall show the following:

- The installation number and the location of the corresponding Plant on Site;
- The height in metres, above the pump of the highest hydrant or hose reel fed from the pump;
- Each separate building, the relevant details;
- The calculated hydraulic criteria of the installation(s);
- By means of colour shading or hatching, the area covered by each installation and, if required by the fire brigade, the routes through the premises to those areas; and
- The location of subsidiary valves.

All fire signs such as stack storage heights, terminal test points, valve location plates, block plans, operating instructions and so forth are to be fabricated from material such as anodised aluminium or chromodeck.

A39.3.2 Pump Suction Tanks

A minimum of 1250 l/min and 30 l/min must be supplied to the furthest hydrant and hose reel respectively. The minimum water storage must cater for this and be stored in at least two equal tanks. The minimum storage capacity shall be 75 000 litres. The supply to these tanks shall be adequate to fill it all within 36 hours. If, with the supply available, the tanks cannot be refilled at the above rates, the capacity of effective stored water must be increased by one third in excess of the calculated requirement or by the appropriate amount of the shortfall, whichever is the greater.

The suction tanks shall be subdivided into two equal divisions so that 50% of the required supply shall be available during maintenance and shall be in line with the ASIB 12th Edition Standards. Where there is a discrepancy between this specification and the provisions of the ASIB 12th Edition set of rules, the latter takes precedence.

Provision must be made for each section of the suction tank to be isolated for cleaning and maintenance purposes.

There must be means available to refill the tank automatically. In order to measure the inflow, a direct reading flow measuring device shall be fitted to the water inlet pipe.

Flow control for tank in-fill and all other associated valves shall be readily accessible for exercising, testing and maintenance.

All steelwork, including any roof steel of a suction tank shall be protected against corrosion. This shall include sand-blasting, priming and coating making use of an epoxy paint.

Content gauges must be provided which shall be an indicator of the flag and ball float type or other approved indicator type, showing the depth of water therein. The use of glass or plastic tube which indicates the level of the water is not acceptable due to clouding.

Overflow pipes and drainage facilities must be provided. Where necessary these shall be taken to a suitable drainage point.

Tanks must be completely enclosed with a roof to exclude daylight and to ensure that water does not become contaminated with extraneous matter.

An easily accessible roof hatch with a minimum dimension of 750 mm shall be provided for the roof. A substantial lockable catch shall be fitted to the cover to keep it closed.

Outside and inside steel ladders for convenient passage from one to the other and through the roof hatch shall be provided. Ladders shall not interfere with the opening of the roof hatch cover and shall not incline outward from the vertical at any point.

A main bypass connection shall be provided. The connection is to be taken to the delivery side of the pump downstream of the non-return and isolating valve. The bypass shall be the same diameter of the water supply connection and shall be fitted with a non-return valve. Isolating valves, chained in the closed position, shall be fitted on the upstream and the downstream side of the non-return valve.

Where necessary, provision shall be made at the point where the supply water enters the tanks for suitable baffles to ensure the minimum entrainment of air.

The pump suction tank suction pipe shall be fitted with a suitable vortex inhibitor which allows for the low water level of a suction tank to be taken as the underside of the flange attachment to the suction pipe.

A39.3.3 Pumps

(a) General

All pumping systems shall operate automatically and must conform to this specification and the ASIB 12th Edition Standard.

Pumps shall start automatically and shall be stopped manually.

(b) Pump Room

The pump room shall be constructed from concrete and shall be watertight.

Adequate ventilation must be provided to limit the temperature rise in the pump room to not more than 10° Celsius above the ambient temperature under stationary to engine or motor full load conditions.

The pump room must be locked at all times and a notice stating where the keys are obtainable must be mounted on the door.

Sufficient natural and artificial light shall be provided in the pump house. Access doors are not acceptable as providing natural lighting.

As a diesel engine is being used, the pump house must have adequate mechanical ventilation for engine aspiration. Louvers or air bricks alone are not deemed to provide adequate ventilation. It must be ensured that the following minimum air changes take place:

Size of engine	**Minimum air changes**
2 and 3 cylinder naturally aspirated or air cooled	6 m³ per minute
4 cylinder naturally aspirated	6 m³ per minute
4 cylinder turbo charged	6 m³ per minute
6 cylinder naturally aspirated	6 m³ per minute
6 cylinder turbo charged	12 m³ per minute
8 cylinder engines	15 m³ per minute
Above 7 litre capacity	20 m³ per minute

Provisions shall be made for natural drainage of the pump room. The cooling water from the engine jacket and the leak off water from the pumps shall be taken to a point outside the pump room. If required, a sump pump must be provided and a warning device fitted at the top of the sump.

The size of the pump house must be adequate to allow easy access to pipe work, pump units and controlling Plant.

All pressure gauges within the pump house must be glycerine filled with a dial face of not less than 100 mm.

To minimise the amount of time the fire pump is inoperative for maintenance or other reasons there shall be a suitable number of flanged joints on the pipe work to allow any of the Plant to be removed for overhauling or replacement.

All pipe work must be suitably supported with at least one support on both suction and delivery as close to the pump casing as possible and no strain shall be imposed on the pump casing by the pipe work. It shall be possible to unbolt suction and delivery flange bolts on the pump and no visible movement shall be observed in the pipe work at this time.

The pump and driver shall be mounted on a common base plate and connected by the means of a flexible coupling. A suitable coupling guard shall be fitted. Provision shall be made for suitable lifting lugs permanently attached to the base plate.

The base plate shall be securely attached to a solid foundation of reinforced concrete.

(c) Suction Pipework and Fittings

All suction lines shall be fitted with suitable strainers / dirt catchers.

Means must be provided for the release of air which might become trapped in the upper part of the pump case.

Bends in the suction pipe work shall be kept to a minimum. Bends shall be of the swept long radius type having a radius of curvature of not less than twice the diameter of the suction pipe plus 100 mm.

Isolating valves shall be installed on all the pump suction pipes in suitable locations to allow servicing and maintenance of all Plant.

To provide relief from the strain when the pump and its suction supply are on separate foundations with rigid interconnecting pipe work, there shall be at least one approved flexible coupling on the suction pipes.

A glycerine filled compound pressure and vacuum gauge having a dial not less than 100 mm in diameter shall be connected to the suction pipe either in the position provided by the pump manufacturer or as near to the pump casing as possible with a 10 mm isolating gauge valve. The face of the dial shall read in kilopascals and have a maximum pressure range of minus 100 kPa to plus 150 kPa.

Under standard conditions, the diameter of the suction pipe must be such that a velocity of 1.8 metres per second is not exceeded when the pump is operating at maximum flow rate.

(d) Delivery Pipework and Fittings

A non-return valve shall be installed on all pump delivery assemblies.

An isolating valve shall be installed on the downstream side of the non-return valve to make the non-return valve and pump accessible for repair.

A glycerine filled pressure gauge having a dial not less than 100 mm in diameter shall be connected to the delivery pipe work between the non-return valve and the pump delivery via a 10 mm isolating gauge cock. The face of the dial shall read in kilopascals and have a pressure range of at least twice the rated working pressure of the pump.

All pump delivery isolating valves must be of the gear driven butterfly type and secured in the open position by 25 mm link chains and keyed alike padlocks.

All pump delivery pipe work, inclusive of the installation pipe work, must be pressure tested to at least one and a half times the working pressure of the systems.

(e) Jockey or Make-up Pump

A jockey or make-up pump must be fitted to maintain pressure in the system.

They shall be of centrifugal pump design having a discharge pressure sufficient to maintain the desired fire protection system pressure. It shall have steep head to capacity characteristic to avoid excessive flow when pumping within the pressure operating range.

The jockey pump must be sized to prevent this pump from maintaining two fire hose reels in operation without the main fire pump starting, plus the normal leakage rate.

The jockey or make-up pump pressure operating range shall not exceed 1 000 kPa and shall not be less than the pressure switch setting to start the fire pump.

The jockey or make-up pump shall be set to start automatically when the pressure in the system has fallen to a value of not less than 85% of the churn pressure of the primary pump and to shut off automatically when the system pressure has reached either the jockey or make-up pump churning pressure or 1 000 kPa, whichever is the lesser.

A fire pump shall not be used as a pressure maintenance pump.

The suction pipe for the jockey or make-up pump shall be taken from the side or top of the main fire pumps common suction line.

A non-return valve shall be installed in the jockey or make-up pump discharge pipe.

Isolating valves shall be installed in such places as required to make the jockey or make-up pump and non-return valve along with other miscellaneous fittings accessible for maintenance and repair.

Means must be provided to reduce the applied water pressure to the jockey or make-up pump starting device to simulate the conditions of automatic starting and stopping at the requisite pressures.

(f) Pump Selection, Materials and Operation

The nominal duty of the pump (diesel) shall not be less than the values below:

- **Flow of 1250 l/min at 600 kPa** (to be confirmed hydraulically prior to final ordering).

The performance characteristics of pumps shall be such that the pressure falls progressively with the rate of demand, so that whilst being capable of providing the rate of flow and pressure required at the highest and most remote parts of the protected premises, the output will be so controlled that there is not an excessive rate of discharge at the lowest level in areas close to the installation valves.

It shall be ensured that the differential between the NPSH available and the NPSH required will not be less than 1.5 metres.

The closed outlet valve pressure, under installed conditions must not exceed 1 000kPa. In selecting pump characteristic curves, allowance shall be made for the increase in pressure at zero flow due to an increase in shaft speed of the prime mover and for an increase or decrease in pressure due to a positive or negative pressure at the pump suction flange.

Pumps shall be of centrifugal horizontal shaft design.

Where the following pump parts are used, the following materials shall apply:

Part	**Material**
Bearings	Ball / Roller
Casing	Cast Iron
Case wear rings	Bronze
Gland	Bronze
Gland packing	High Grade Graphite Cotton
Impeller	Bronze
Lantern Rings	Hi-dur
Mechanical Seals	Carbon Ceramic
Shaft	E N 8 Steel
Shaft sleeves	Bronze
Stuffing box bushes	Bronze

For end suction pumps bronze case wear rings shall be fitted to the pump casing.

Cast iron shall not be used for any wetted rotating component or stationary part in close running contact with the rotating member.

All pump parts shall be standard stock items with no special treatment, i.e. impeller under-filing, polishing or other changes are not permissible.

For end suction pumps it must be ensured that the bearing housing is adequately supported.

The coupling between the engine or motor and the pump must allow each unit to be removed without disturbing the other.

The pump shall be fully operational within 15 seconds after starting.

Pumps must have a direct drive and must start automatically.

The automatic starting device for pumps must be of an approved pattern and set to operate the primary pump when the pressure in the trunk main has fallen to a value not less than 80 per cent of the pressure of the primary pump when churning.

Means shall be provided for manual starting by reproducing the pressure reduction. Once started, the pump must run continuously until stopped manually.

A fall in water pressure in the fire water system, which is intended to initiate the automatic starting of the pumps shall at the same time provide a visual and audible alarm in an area with responsible manning. The starting of the pump or pumps shall not cause the cancellation of the alarm. The visual and audible alarm shall form part of an alarm system and shall be initiated by electrically separate contacts. These contacts shall consist of one change over moving contact and two fixed contacts, one normally open and one normally closed, or two completely separate contacts, one normally open and one normally closed. The contacts shall be wired to clearly identified terminals on the terminal strip of the controller. The contacts shall be of the positive make or break type, but the alarm system shall be designed to operate on “fleeting” signals and shall latch on to either momentary make or break signals.

In all cases each pump must be provided with a plate stating the following:

- The churn pressure of the pump;
- The calculated flow rating;
- The pressure at the calculated flow rating;
- The pump model number;
- The pump serial number;
- The impeller diameter;
- The rotational speed; and
- The maximum power absorbed at the flow rate given.

Where the performance characteristic is achieved with an orifice plate not integral with the pump delivery, the plate must carry a reference to the fact that the performance given is that of the pump and orifice plate combination, together with the K-factor of the orifice plate calculated in accordance with accepted formulae.

Sufficient water must be permitted to circulate when the pump is running to prevent it from overheating when operating against a closed discharge valve. The quantity of water discharged may not be less than the equivalent of 10% of the numerical kilowatt rating of the prime mover and must be taken into account when sizing a pump. When the pump set is shut down, no water must circulate. In any event the manufacturer must be consulted and his recommendations adhered to. A flow indicator or sight glass must be provided upstream of an isolating valve which shall be locked in its correct operative position.

Means must be provided to reduce the applied water pressure to the starting device to simulate the condition of automatic starting at the requisite pressure.

This can take the form of a drain valve on the hydraulic connection to the pump starting pressure switch and suitable permanent drainage facilities must be provided. In order that the pressure may be dropped at a suitable rate to judge the pump cut in pressure, this drain valve may be fitted with an orifice plug. To facilitate testing and servicing, an isolating valve, with a bypass, shall be fitted on the hydraulic connection. The bypass shall incorporate a 3 mm orifice and a back pressure valve allowing flow towards the trunk main. A glycerine filled pressure gauge with a dial face of not less than 100 mm and fitted with an isolating gauge cock to indicate the pressure at which the pump starts must be placed between the isolating and drain valves in such a position that it can be read during the starting test.

Power sufficient to drive the pump at the required pressure must be available at all times.

Power for the warning systems must be taken from a separately switched sub-circuit to that feeding the pump in the case of the electric motor driven pump. In the case of the diesel engine driven pump, the power for the warning system may not be taken from the battery which is used for automatic starting.

The warning system shall be equipped with its own batteries which shall have an ampere-hour capacity to provide 48 hours of monitoring the complete system and 1 hour of audible and visual alarm. The term “sub-circuit” means a circuit connected to a switch supplied directly from the low or medium voltage bus-bars on the fire pump room distribution board.

(g) Diesel Engine Driven Pump

The diesel engine must be of the compression ignition mechanical injection type capable of being started without the use of wicks, cartridges, heater plugs or ether, at an engine room temperature of 4° Celsius and must accept full load within 15 seconds from the receipt of the signal to start.

The diesel engine must be naturally aspirated, supercharged or turbo-charged and either air or water cooled. Charge air cooling must be water cooled. Radiator cooling is not an acceptable or suitable for South African climatic conditions.

The diesel engine must be capable of operating continuously on full load at the Site for a minimum period of 6 hours.

The diesel engine must be provided with a governor to control the engine speed within 4.5% of its rated speed under any condition of load up to the full load rating.

The diesel engine must not have any manual device fitted to the engine which could prevent the engine starting. Any device must return automatically to the reset position for automatic starting.

The diesel engine must be provided with a tachometer and hour meter which must be permanently attached to the engine or the controller panel.

The diesel engine must be provided with, if necessary, an excess fuel device for the automatic cold starting of the engine. The device is to return automatically to the reset position for automatic starting.

The following are the permitted maximum speeds for a diesel engine:

Diesel engine size	**Maximum speed**
2 or 3 cylinder	2600 rpm
4 cylinder naturally aspirated	2400 rpm
4 cylinder turbocharged	2200 rpm
6 cylinder naturally aspirated	2400 rpm
6 cylinder turbocharged	2200 rpm
8 cylinder	1800 rpm

The diesel engine selection must be based on the continuous rating in accordance with BS 5514 or DIN 6271 B2 or SA Equivalent.

An extended accessible fuel stop control or other approved means, clearly labelled must be manually operated and return automatically to the starting position after use.

(h) Cooling System

The following systems are acceptable:

- Cooling by water from the fire water pump direct into the engine cylinder jacket(s) via a regulating valve of not less than 10 mm diameter to limit the applied pressure to a safe

value as specified by the engine manufacturer. The outlet connection from this system must terminate at least 150 mm above the engine water outlet pipe and be directed into an open tundish or sight glass so that the discharge water is visible;

- A heat exchanger, the raw water being supplied from the fire water pump via a regulating valve, of not less than 10 mm diameter, if necessary, to limit the applied pressure to a safe value as specified by the engine manufacturer. The raw water outlet connection from this system must terminate at least 150 mm above the water outlet pipe and be directed into an open tundish or sight glass so that the discharge water is visible. The water in the closed circuit must be circulated by means of an auxiliary pump driven from the engine and the capacity of the closed circuit must not be less than that recommended by the engine manufacturer. If the auxiliary pump is belt driven, there must be multiple belts such that should half the belts' break, the remaining belts must be capable of driving the pump; and
- Direct air cooling of the engine by means of a multiple belt driven fan. When half the belts are broken, the remaining belts must be capable of driving the fan.

Any valve on the cooling water must be so designed that under a fully closed position, it will allow the correct amount of water required by the engine manufacturer to pass through it for cooling purposes.

The cooling water line must have a suitable strainer fitted prior to entry into the engine jacket or heat exchanger.

All cooling water pipes must be of galvanised steel or copper.

The total water consumption rate for cooling the engine either directly through the cylinder jackets or as raw water supplied to a heat exchanger plus the cooling water consumed to prevent the pump overheating whilst churning must be taken into account when sizing the units.

Where engines use cooling water from the pump discharge, a vee-port flow regulating valve(s) with non-corrosive internals must be fitted to prevent excessive pressure on the engine cooling system. The regulating valve(s) must be set during site commissioning and locked in the “set-open” position to limit the applied pressure to a safe value as specified by the engine manufacturer. Once pre-set, the regulating valve must be completely enclosed in a locked housing to prevent the valve working loose due to general vibration of water movement or tampering. A 0-250 kPa, glycerine filled pressure gauge shall be fitted in the line between the regulating valve(s) and the inlet to the engine jackets or heat exchanger. To prevent an excessive build-up of pressure in the engine jacket, no thermostat device is to be fitted and the cooling water lines between the “set-open” regulating valve on the inlet side and the ultimate open discharge shall be free of any other valves or restrictive fittings.

A flow indicator sight glass or tundish shall be fitted on the engine cooling water discharge pipe. The piping must not be returned directly to the pump suction branch. In all cases care shall be taken to ensure that no flow through the engine jacket takes place whilst the engine is stationary. Spring loaded or electrically operated devices are not permitted.

The air intake must be fitted with a filter of adequate size to prevent foreign matter entering the engine and must be protected from water discharge where sprinklers are fitted in the engine room.

(i) Exhaust System

The exhaust must be fitted with a suitable silencer and the total back pressure shall not exceed the engine manufacturer’s recommendation.

Where the exhaust system rises above the engine, means must be provided to prevent any condensate flowing into the engine.

The exhaust system must run at least 300mm above engine base plate level.

The engine exhaust system shall be lagged or guarded, as necessary, for the safety of personnel. Attention is drawn to the need to ensure that the point of exit of the exhaust pipe from the engine house does not pose any fire risk to the structure, and that exhaust fumes cannot be drawn into the engine house or into any occupied building.

(j) Fuel Tank

The fuel tank must be of welded steel conforming to British Standard 814:1 or SA equivalent for Mild Steel Drums.

The tank must be mounted above the engine fuel pump.

The capacity of the tank must be sufficient to allow the engine to run on full load for 6 hours.

Fuel tanks must not be fitted to or above either the engine or the batteries, neither must they be positioned such that any spillage or leakage from the fuel tank can come into contact with any hot surface on the engine.

The fuel tank may be fitted above the end of the pump set furthest away from the pump house or outside the pump house.

Pipes that carry lubricating oil or fuel oil shall be of metal or suitable fire resistant material.

Any valve in the fuel feed pipe between the fuel tank and the engine must be placed adjacent to the tank and it shall be locked in the open position. Pipe joints must not be soldered and plastic tubing must not be used.

The following must be provided:

- A sludge and sediment trap;
- A readily visible fuel level gauge which must not be of the glass or plastic tube level indicating type;
- Damage or fracture of the fuel level gauge must not result in fuel spillage;
- An inspection and cleaning hole;
- A filter between the fuel tank and fuel pump mounted in an accessible position for cleaning; and
- Means to enable the entire fuel system to be bled of air.

Air relief cocks are not allowed, screwed plugs are permitted.

(k) Starting Mechanism

Provision must be made for two separate methods of engine starting. Two separate batteries of adequate capacity must be provided for automatic and manual starting of the engine. Where

electric starting is used, the system must operate from a battery supply recommended by the engine supplier.

Automatic starting shall be by means of a battery powered electric starter motor of the axial displacement type having no retaining catches or inertial features. The pinion must rotate at reduced speed during the process of engagement with the flywheel ring, but during the initial engagement the pinion and armature shaft assembly must mesh by moving axially towards the gear ring. The starting sequence must be initiated by a fall in pressure in the water supply pipe to the fire water installation, and repeat engagement facilities must be provided should the starter pinion fail to engage with the engine flywheel ring.

When the engine fires, the starter motor pinion must be withdrawn from the flywheel ring automatically by means initiated by a directly driven tacho generator or centrifugal speed switch or proximity switch. Flexible drives are not permitted. Battery charging, voltage generators, alternators and pressure switches on the engine lubricating system or water pump outlet, as a means of de-energising the starter motor, are not permitted.

The starter motor in combination with each battery power supply shall have a design capability to rotate the engine for at least 3 minutes or 12 cycles of not less than 15 seconds cranking and not more than 6 seconds rest.

(l) Batteries

Batteries shall be mounted and securely clamped against displacement on wooden base stands or stillages and located in a readily accessible position where the likelihood of contamination by oil, fuel, damp, pump set cooling or flooding water or being damaged by vibration or mechanical means is unlikely. The battery shall be installed as close to the starter motor as possible to minimise voltage drops between the battery and starter motor terminals.

Current carrying parts shall be at least 300 mm above finished floor level.

Dual, continuously rated, heavy current solenoid operated contactors for connecting the batteries to the engine starter motor shall be located on the engine or bedplate immediately adjacent to the engine starter motor or batteries.

Sealed maintenance free batteries only are acceptable.

A built-in hydrometer shall be provided to enable the state of the batteries to be determined. An information chart pertaining to the built-in hydrometer must be mounted on the battery case.

Each battery used for starting must be of a type suitable to accommodate the method of charging with an expected life of approximately 4 years and not less than 3 years with a capacity to provide 3 minutes continuous cranking or 12 cycles of cranking a cold engine of 4° Celsius according to the method of starting employed.

Batteries not used for the automatic starting of diesel engine-driven pumps, when fully charged and disconnected from the charger, shall be of sufficient capacity to monitor of all specified circuits in accordance with this tender document.

Any battery used for an automatic power failure alarm shall not be used for the automatic starting of a diesel engine driven pump or for any purpose other than protection against fire.

(m) Battery Chargers

The battery voltage shall be as specified by the engine manufacturers, 24 volts are preferred, but 12 volts are acceptable.

The means of charging the batteries must be by a fully automatic continuously connected constant voltage, constant current charge having automatic trickle and boost charge facilities.

The Plant must indicate that each battery and the relevant charger circuits are connected and carrying direct current.

The charging rate shall be set so that the battery does not gas excessively at any stage during the charging and the rate shall be automatically adjusted to suit the state of the battery.

The circuits of the batteries must not be linked so that power may be transferred from one to the other.

The charger must have self-resetting overload protection and shall be capable of operating on a short circuit.

The charger shall operate on a short circuit and operate even when the battery is totally flat.

The charger shall float a fully charged battery continuously.

The charger shall be designed to be protected against damage when an attempt is made to charge a reverse connected battery and shall initiate an alarm when the charger output has failed.

(n) Tools and Spare Parts

A standard kit of tools as recommended by the engine manufacturer must be provided with the engine and kept on hand at all times.

Spare parts recommended by the engine manufacturer must be supplied with the Plant.

(o) Deration Factors

The following deration factors must be allowed for when determining the kilowatt output of the diesel engine:

Altitude Deration	
Naturally Aspirated Engines:	3,5% every 300 metres above 150 metres above sea level
Turbo Charged Engines:	1,5% every 300 metres above 150 metres above sea level

Temperature Deration	
Inter-cooled Turbo Charged Engines:	1% every 300 metres above 150 metres above sea level

Temperature Deration	
Naturally Aspirated Engines:	2% every 5,5° Celsius above 30º Celsius ambient
Turbo Charged Engines:	3% every 5,5° Celsius above 30º Celsius ambient
Intercooled Turbo Charged Engines:	1% every 5,5° Celsius above 30º Celsius ambient

The engine shall have 10% power in excess of that absorbed by the pump at 110% of the calculated maximum flow after deductions for altitude, temperature and ancillary components using the continuously rated curve at the engines selected speed.

Power available shall be understood as the net power at the driver shaft after derating for altitude and temperature, and for engines and auxiliary drives such as fans and cooling water pumps.

A39.4 ELECTRICAL INSTALLATIONS

A39.4.1 General

Each pump room shall be equipped with a distribution board which shall be designed to interrupt the fault current. The board shall be fitted with current limiting devices to ensure that the controller, monitoring panel or any other accessory which is connected to the switchboard is afforded suitable short circuit back up protection.

The distribution board shall be fitted with a separate switched fuse unit or circuit breaker of suitable rating to supply each:

- MV Electric drive controller;
- Compression-ignition engine drive controller;
- Jockey pump controller;
- Pump room monitoring panels;
- Pump room heating circuits;
- Pump room lighting circuits;
- Pump room plug circuits; and
- Accessories.

Taking of power for light and plug circuits or any other devices from drive controllers or monitoring panels is strictly prohibited.

Power supplies shall be protected by means of suitably rated switch-fuse units or circuit breakers on the main HV or MV switchboards. These protective devices shall be clearly labelled:

FIRE PUMP POWER SUPPLY

NOT TO BE SWITCHED OFF IN EVENT OF FIRE

The lettering shall be in 25 mm capitals.

The pump room MV switchboard, pump drive controllers, monitoring panels, etc., may be incorporated in one common panel within the pump room, provided that general arrangement drawings, detailed wiring diagrams, component scheduled and operating instructions are submitted to the Engineer for approval.

Separately switched power sub circuits shall be used to supply power:

- For alarm devices connected to pump(s) and for any mains failure alarm system; and
- For any pump that would be the first to come into operation because of a drop in the fire water installation pressure and any mains-powered low-water pressure alarm system.

The indicating Plant shall be mains-powered by an uninterruptible power system that complies with the requirements of SANS 1474.

A39.4.2 Cables and Wires

Electric cables shall be:

- Suitable for sprinkler use;
- Selected, handled and installed in accordance with SANS 10198-2; SANS 10198-4 and SANS 10198-8;
- Protected from direct exposure to fire; and
- Rubber-insulated and rubber-armoured, or enclosed in steel conduit, or mineral- insulated and copper-sheathed.

Electrical wires shall:

- Be single core, PVC-u-insulated, annealed copper conductors of 600 V grade in accordance with SANS 1507;
- Be continuously rated;
- Not use conductors that have fewer than seven strands or that are of cross-sectional area less than 2.5mm^2;
- The following are normally deemed suitable for these type of installations (depending on the particular application):
    i) Wiring and wireways that comply with the requirements of SANS 529, SANS 950 and SANS 1065: Part 1.
    ii) Cross-linked polyethylene-insulated (XLPE-insulated) electric cables that comply with the requirements of SANS 1339; and
- In the case of cables to motors inside buildings, cables that are:
    i) Armoured and rubber-insulated in accordance with the requirements of SANS 1574; or
    ii) Enclosed in screwed steel conduit and that are rubber-insulated in accordance with the requirements of SANS 1574 or that are mineral-insulated and copper-sheathed; and
    iii) Wireways for electrical cables that comply with the requirements of SANS 1197: Part 1.

Steel conduit shall be threaded in accordance with the requirements of SANS 1306: Part 1.

External overhead cables are not permitted.

A39.4.3 Circuit Breakers and Switches

Circuit breakers, isolators and switches shall be suitable for sprinkler use.

Moulded-case circuit breakers shall comply with the requirements of SANS 156 and earth-leakage protection units shall comply with the requirements of SANS 767: Part 1.

The following are deemed suitable for sprinkler use (depending on the particular application):

- Electrical switches that comply with the requirements of SANS 60669: Part 1;
- Moulded-case circuit breakers that comply with the requirements of SANS 156;
- High-voltage AC circuit breakers that comply with the requirements of SANS 60056;
- Manually operated air break switches that comply with the requirements of SANS 152;
- AC disconnectors and earthing switches that comply with the requirements of SANS 60129; and
- Electrical high-voltage switches that comply with the requirements of SANS 60265: Part 1 and SANS 60265: Part 2.

A39.4.4 Fuses, Fuse Cartridges and Fuse Switchgear

Fuses, fuse cartridges and fused switchgear shall be suitable for sprinkler use.

Fused switchgear that complies with the requirements of SANS 60298 is normally deemed suitable for sprinkler use (depending on the particular application).

A39.4.5 Busbars, Contactors, Fused Switchgear and Instruments

Busbars, contactors, fused switchgear and instruments shall be suitable for sprinkler use.

The following are deemed suitable for sprinkler use:

- Busbars that comply with the requirements of SANS 1195; and
- Electrical terminals and connectors that comply with the requirements of SANS 1433: Part 1 or SANS 1433: Part 2.

A39.4.6 Power Supplies

(a) General

Control and monitoring panels shall be designed for an electrical fault level of 31MVA at 400V, three-phase 50 Hz.

In the case of diesel engine drive controllers, the following shall apply:

- All DC electrical components shall be capable of functioning effectively at the reduced voltage levels that occur during engine cranking; and
- Relays shall not chatter on drop-out and solid state circuits shall not "switch" under reduced voltage conditions.

The battery power supply for indicator panels or alarm systems shall not be supplied from the batteries provided to start the diesel engine(s).

The Plant and materials shall be installed in accordance with SANS 10142: Part 1 and shall comply with the requirements of the Occupational Health and Safety Act, 1993 (Act 85 of 1993).

Power supply voltages, currents and insulation levels for these installations shall comply with the requirements of SANS 1019.

Power supply circuits that serve sprinkler or fire water Plant and services shall function independently of any other main or sub-main circuits that do not serve the fire water installation.

Power for light and plug circuits or any other device shall be not taken from drive controllers or monitoring panels.

(b) Main Power Supplies

The power supply shall be obtained from a public electricity supply or other suitable reliable source. Diesel engine driven generator sets are not classed as a reliable source.

If the electricity supply is not taken from a public source, full particulars of the generating plant shall be submitted to the Engineer at the planning stage.

Main power supplies for the installation shall be taken direct from:

- The main high voltage (HV) switchboard for HV electric motor-drive controllers; and
- The main medium voltage (MV) switchboard for all MV Plant.

The power supplies for the pump room shall be derived direct from:

- The main HV switchboard, in the case of the HV electric motor-driven controllers; and
- The main MV switchboard, in the case of the pump room MV switchboard

The power supply circuit for electric motor-driven pumps shall be separate from all other circuits in the premises.

Power to drive the pumps shall be available at all times.

All wiring associated with the electric motor-driven pump shall be in accordance with SANS 10142.

(c) Protection

The protection of the main and the control circuit power supplies shall be:

- Designed to suit a design fault level of 31 MVA at 400 V three-phase 50 Hz in situations of varying fault levels; and
- Provided with either high-rupturing capacity fuses of suitable rating or circuit breakers of suitable rating and breaking capacity (or both).

Switches that control the power supplies shall be readily accessible to the fire brigade.

Power supply connections to any fire water Plant or services shall incorporate suitable isolating protective devices and these devices shall be secured against unauthorized operation.

Separately switched fuse units or circuit breakers of suitable rating shall, for example, shall be provided for all electric drive controllers, diesel engine drive controllers, jockey pump drive controllers, pump room monitoring panel(s), pump room heating and lighting circuits and plug circuits.

Power supply connections to the pump room shall be protected by means of suitably rated switch fuse units or circuit breakers to interrupt the fault current on the HV or MV switchboards.

The following shall apply in the case of electric motor-driven pumps:

- The electricity supply to motors shall incorporate fuses of high-rupturing capacity that are capable of carrying the stalled motor current for a period of not less than 75 % of the period needed for the motor windings to fail; and
- Any no-volt release mechanism shall be of the automatic resetting type so that, on restoration of the supply, the motor can be restarted automatically if the trunk main pressure falls.
- Magnetic and thermal overload trips shall be not used.

(d) Control Panels

Control circuit power supplies shall be maximum of 220 V AC or 24 V DC and shall be derived from a separate suitably rated double wound air cooled transformer within the enclosure of each controller, monitoring panel or power supply unit.

Current-carrying parts of any control circuits and panels shall be at least 300 mm above floor level.

(e) Electrical Earthing

All exposed metalwork in installations shall be efficiently earthed to prevent the metalwork from becoming electrically charged.

Fire water pipe work shall be not used as a means of earthing electrical Plant.

Electrical Plant below sprinkler installations shall have normal earthing and overload protection.
Fire water installation metalwork and metal wire-ways for electric cables shall be efficiently connected to the main earthing terminal of the electrical installation.

(f) Cables and cable routes for electrically driven pumps

External overhead cables shall be not used for electrically driven pumps.

To protect cables from direct exposure to fire they shall be run outside the building, or through those parts of the building where the fire risk is negligible and that are separated from any significant fire risk by walls, partitions or floors with a fire-resistance rating of at least 60 minutes, or they shall be given additional direct protection.

A39.5 PUMP DRIVE CONTROLLERS

A39.5.1 General

Each pump must have its own controller which shall be specifically designed for sprinkler fire pump service and approved by the Engineer.

All pump manufacturers must use the panels which were approved in conjunction with their units.

The controller shall be completely assembled, wired and tested by the manufacturer and an independent authority before delivery from the factory to Site.

The controller shall be labelled and the nameplate shall show the name of the manufacturer, the identifying designation, the complete electrical rating, and the certificate of approval number.

It shall be the responsibility of the Contractor to make the necessary arrangements for the services of a manufacturer representative, when needed, for installation and adjustment of the Plant.

A39.5.2 Labels

Labels shall consist of a composite red / white / red plastic sandwich type to show white letters on a red background. Anodised aluminium type labels with red background are acceptable.

Label descriptions shall be in both English and any other required official language.

The following letter and numeral sizes shall be used for labels:

Label Type	**Letter Height**
Main panel designation	12 mm
Individual component designations	6 mm
Small component designations	3 mm
Control / signal device designations	2,5 mm

Plastic embossed stick-on tape labels are not acceptable.

Labels for control fuses shall indicate function and fuse rating.

Each operating component of the controller shall be marked to plainly indicate the identifying letter or number referenced to the wiring diagram and the markings shall be located so as to be visible after installation.

A39.5.3 Starting and Control

In the control circuit there shall be a pressure actuated switch having high and low calibrated adjustments or two pressure actuated switches, one having high and the other having low calibrated adjustments and responsive to water pressure in the fire protection system. Suitable means shall be made for relieving pressure to the pressure actuated switch, to test the operation of the controller and the pump.

When the pump supplies special water control Plant, (deluge valves, dry pipe valves, etc.), and it is desired to start the pump before the pressure actuated switch(es) would do so, the controller shall be equipped to start the pump upon operation of the fire detection Plant.

The controller shall be wired for manual shut down.

Shut down shall be accomplished by operation of the stop / reset push button on the outside of the control enclosure and, in the case of automatic controllers, shall return the controller to full automatic position.

A39.5.4 Location

The controller shall be located as close as it is practical to the motor / engine it controls and shall be within sight of the motor / engine.

Diesel engine controllers shall be located in a position whereby the fuel shut off lever and controller panel buttons can be accessed simultaneously.

The controller shall be located or protected that it will not be damaged by water escaping from the pump or pump connection.

A39.5.5 Construction

All controller Plant shall be incorporated within a total enclosed, damp, dust and flash proof enclosure in accordance with SABS 0108.

All Plant excepting those items fixed in the door shall be mounted on a removable 2 mm thick rolled mild steel chassis plate which shall be folded and braced to ensure rigidity.

The controller enclosure shall be constructed from 2 mm thick cold rolled mild steel and shall be equipped with a hinged door supported on robust hinges and secured by a sufficient number of substantial catches to ensure proper sealing of the gasket.

The door shall be fitted with a non-deteriorating gasket made from butyl sponge rubber or similar material.

The following shall be provided in a suitable pocket permanently secured inside the enclosure door:

- Wiring diagrams with clearly identifiable letters and numbers for all components and wires;
- Complete component schedule giving wiring diagram reference, make, type, size and supplier; and
- Operation and maintenance instructions.

Complete operating instructions, in English and any other official language that may be required, a wiring diagram and a component schedule shall be mounted in a glazed frame permanently fixed in the pump room.

Electrical terminals and both ends of all wires shall be plainly marked to correspond with the as made wiring diagrams for the controller.

A39.5.6 Compression-Ignition Engine Drive Controllers

The controller shall be labelled: DIESEL ENGINE DRIVEN PUMP CONTROLLER.

All switching Plant for manual use in connecting or disconnecting or starting or stopping the engine shall be externally operable.

A manually operated isolating switch shall be mounted within the controller enclosure.

Fuses for protection of both the AC and DC circuits shall be provided and shall conform to this tender document and the fuse rating shall be in accordance with the Fuse Table.

High rupturing capacity cartridge fuses of suitable rating mounted in insulated withdrawable fuse holders shall be provided for the protection of each branch circuit conductor. The removal or blowing of any HRC fuse will initiate an alarm or fault condition at the annunciator panel.

One complete set of spare HRC fuse cartridges shall be secured on approved brackets inside the enclosure door.

Automatic starting will be initiated by one of two external monitoring devices wired in parallel and the starting components will be arranged to crank for a maximum period of 15 seconds and dwell for a period of not more than 6 seconds. Both time periods shall be adjustable and set to suit engine and site conditions.

A presentable counter arranged to count each cranking period shall be provided and shall be capable of being preset for up to 9 counts, but shall normally be preset for 6 counts. If the engine has not started after the preset number of counts, the cranking must be stopped and the pump failure indication and alarm must be initiated. Only actual cyclic counters are acceptable. A timer set for the overall calculated time for the preset number of starts is not acceptable.

The components shall be arranged to connect each of the two batteries to the engine starter motor on alternate cranking cycles and so designed that the first cycle of a fresh attempted start shall alternate between one battery and the other.

A suitable voltage relay shall be connected across the load side of the main fuses and electrically separate contacts on this relay shall be wired out to clearly identified terminals for initiating the power failure alarm.

An AC voltmeter shall be provided to indicate the input voltage to the controller.

A DC voltmeter shall be provided to indicate the terminal voltage of each battery.

A DC ammeter shall be provided to indicate the charging rate of each battery.

Electrically separate potentially free contacts wired out to clearly identified terminals are to be provided for the following conditions to be monitored:

- Fire alarm;
- Power failure, (battery charger electrical supply);
- Pump failure;
- Pump running;
- Low oil pressure;
- Charger failure, (from both charger outputs in parallel); and
- Control circuit failure, (from the end of the control circuit)

Indication in the form of duplicate indicating lamps shall be provided to show the following:

- Fire alarm;
- Pump failure;
- Pump running; and
- Low oil pressure

A reset push button shall be provided to reset the controller.

The controller shall latch on to a starting signal until the reset push button is pressed.

One “emergency start” push button shall be provided for each battery and the circuitry shall be arranged so that each push button will bypass the automatic starting circuit and will energise its associated starter motor solenoid. It shall be possible to depress both push buttons and apply power from both batteries simultaneously to the starter motor.

An adjustable voltage sensitive device shall be provided to sense the potential generated by the tacho generator. One set of normally open contacts of one voltage sensitive relay shall be wired in parallel with that of the other relay to initiate the pump running relay.

Each engine shall be fitted with two tacho generators taken off different drive points on the engine, or,

A combination of one tacho generator and one proximity sensor may be fitted to the engine to monitor engine motion. Where such a sensor is used, the panel must be fitted with a matching sensing relay with one set of normally open contacts to be wired in parallel to those of the voltage sensitive relay to initiate the pump running relay.

Manual isolating and/or selector switches in the battery to engine starter motor circuits are not permitted.

A separate test button shall be provided to initiate the automatic starting sequence.

Controllers mounted on the engine bedplate shall be supported by a substantial frame securely bolted to the engine bedplate and the controller shall be secured to this frame by means of approved resilient mountings.

Plug-in components such as fuses, relays, pc boards, etc., in controllers which are mounted on the engine bedplates shall be provided with suitable spring clips or securing facilities to prevent unplugging due to vibration. The removal of any relay must initiate either a “Fault” condition or the “Control Circuit Failure” alarm at the annunciator panel.

All DC electrical components shall be capable of functioning effectively at the reduced voltage levels that exist during cranking. Relays shall not chatter or drop out and solid state circuits shall not “switch” under these low voltage conditions.

The control circuit shall be arranged to operate across the full battery voltage. Connections for any reduced voltage shall not be taken by tapping-off cells in the battery.

The controller shall be equipped with one battery charger in accordance with this tender document for each battery.

A39.5.7 Electric Motor Driven Jockey Pump Controllers

The controller shall comply with the paragraphs pertaining to the electrical installations and general section pertaining to pump drive controllers.

The controller shall be labelled: JOCKEY PUMP CONTROLLER

Starting and stopping of the motor will be initiated by a pressure actuated switch having high and low calibrated adjustments and which is responsive to water pressure in the fire protection system. Suitable means shall be made for relieving pressure to the pressure actuated switch to test the operation of the controller and the pump.

The controller shall be fitted with the following:

- Suitably rated triple pole isolators with auxiliary contacts as may be necessary;
- Suitably rated contactors;
- Adjustable, ambient temperature compensated thermal overload relay for motor protection;
- Hand / auto selector switch; and
- A timer with a 0 to 30 second setting normally set to 20 seconds.

When the hand / auto selector switch is in the hand position, the pump shall run continuously, and when the switch is in the auto position, the pump will start and stop automatically under the control of the pressure switch.

Selector switches incorporating off positions are not acceptable.

A39.6 ANNUNCIATORS FOR PUMP ROOM INSTALLATIONS

A39.6.1 General

The controller shall be labelled: PUMP HOUSE ANNUNCIATOR PANEL

The pump room shall have its own annunciator panel, audible and visual signalling devices and, where required, a repeater panel, all of which shall be approved by the ASIB.

Unapproved audible and visual signalling devices such as sirens, bells, hooters, beacons and lamps will not be accepted for use in conjunction with approved annunciator and repeater panels.

It shall be the responsibility of the approved fire water installer to make the necessary arrangements for the services of a manufacturer representative, when needed, for installation and adjustments of annunciator and repeater panels and Plant.

Each component of the alarm or annunciator and/or repeater panel shall be marked to clearly indicate the identifying letter or number referenced to the wiring diagram and the markings shall be located so as to be permanently visible after installation.

All circuits, including the pressure switches and battery connections, shall be monitored as follows:

- Open circuits shall indicate a “fault” condition;
- High impedance closed circuits shall constitute a normal condition and no indication is required; and
- Short circuits shall indicate an “alarm” or “warning” condition.

A “fault”, “alarm” or “warning” as described above shall initiate the audible alarm which shall be silenced by means of an “accept” push button.

When a “fault”, “alarm” or “warning” condition occurs, the circuit annunciator shall flash on and off until the signal has been accepted, when the annunciator will change from a flashing to a steady visual signal. When the circuit is restored to a normal condition as described above, the steady signal shall extinguish.

A first alarm condition must cause the audible alarm to sound and, after acceptance, a second alarm must again cause the audible alarm to sound. Systems in which the audible alarm is negated after acceptance will not be approved.

The pump house repeater panel shall be mounted in an approved position at a responsibly manned location in the plant or on the premises.

The two audible and one visual signalling device shall be mounted immediately outside the pump room in an approved position.

The audible range of the two audible signalling devices shall be adequate to suit the distance to be covered and the noise environment of the location. Where this is not practical, a repeater panel as described in this tender document must be installed at a permanently manned position.

A steady audible alarm and a flashing visual alarm shall be initiated when a “fire” condition exists. An intermittent audible alarm shall be initiated when a “pump failure” condition exists.

The “Pump House Protection” alarm shall initiate the steady audible and flashing visual alarms.

The signalling devices shall be suitable for operation from the battery powering the annunciator system.

Battery chargers and batteries shall not be housed in the same enclosure as the annunciator or repeater panels.

The charger and batteries may be housed in a common enclosure but in separate compartments suitably divided and sealed to ensure that charger components are not subjected to battery fumes.

A39.6.2 Pump House Remote Alarm Notification and Data Logger Module

The pump house shall be equipped with a remote alarm notification and data logger module to enable remote monitoring of the pump house events and retrieval of data.

The data logging module shall:

- Have the ability to locally log all events that occur within the pump house facility;
- Have the ability to remotely log all events that occur within the pump house facility;
- Send pump house alarms to personnel via SMS or pager; and
- Send pump house alarms to a computer via SMS or pager.

The remote alarm module device shall be located inside the pump house within a metal IP55 enclosure. All controller panels shall have the remote alarm module factory fitted during panel construction before ASIB certification tests.

The hardware product must operate independently from all installed panel systems, i.e. Electric, Diesel, Annunciator or Jockey controllers. The device shall send alarm notification messages via cell phone SMS or pager to both personnel, and or remote offsite computers. The device must have the capability log events internally if pager or cell phone services are unavailable.

The remote alarm module shall conform to the following technical specifications:

- Store up to 1000 events internally on a FIFO (First in first out) basis;
- Both a local and remote event log upload facility to obtain log files;
- A Minimum of 6 personnel contact numbers. (Cell phone or pager);
- A minimum of 20 potential free (dry contact) alarm inputs;
- A minimum of 2 relay outputs (2A);
- A minimum of 4 counters and timers so that required pump house rules can be defined; and
- A 24/7 schedule for daily tests and weekly statistic reports.

The remote logger shall conform to the following pump house alarm rules:

- If the jockey pump runs longer than 5 minutes then send an alarm;
- If the jockey pump starts more than 10 times within a 1 hour period then send an alarm; and
- If the system is in maintenance mode then disarm the cell phones or pagers.

To facilitate weekly tests the panel must have a maintenance button that disables remote alarms messages to cell phones or pagers while the pump house is being tested or repaired, however data is still logged on a remote computer for hard copy test reports.

The following are deemed to be the minimum alarms that shall be monitored:

ALARM MONITORING		
1	Panel	Maintenance MODE SWITCH
2	Jockey Controller Panel	ALARM – Pump RUN
3	Jockey Controller Panel	ALARM – Pump FAIL
9	Diesel Engine Driven Pump Controller Panel	ALARM - Fire ALARM
10	Diesel Engine Driven Pump Controller Panel	ALARM - Pump RUN
11	Diesel Engine Driven Pump Controller Panel	ALARM - Pump FAIL
12	Diesel Engine Driven Pump Controller Panel	ALARM – Mains FAIL
13	Diesel Engine Driven Pump Controller Panel	ALARM - Control Circuit FAIL
14	Diesel Engine Driven Pump Controller Panel	ALARM - Low oil pressure FAIL
15	Diesel Engine Driven Pump Controller Panel	ALARM - Battery charge FAIL
16	Diesel Engine Driven Pump Controller Panel	ALARM - Engine over temperature FAIL

Alarm inputs are to be connected directly to the electric, diesel, jockey or annunciator panels.

All alarms signal wires shall be potential free, (dry contact).

No voltage shall be sent to, or received from the existing pump house panels.

If the unit is in a standalone cabinet it must operate from its own power source.

A39.7 TESTING

Each complete engine and pump set must be tested on the suppliers test bed and the Engineer must be notified 10 days in advance for possible witnessing. .

Copies of test certificates showing at least the following must be provided to the Engineer.

(a) Pump

- Pump manufacturer;
- Pump model;
- Pump serial number;
- Pump impeller diameter;
- Pump efficiency curve;
- Duty flow;
- Pressure at duty flow;
- Nett Positive Suction Head required at duty flow; and
- Power absorbed at duty flow.

(b) Diesel Engine

- Make of engine;
- Speed of engine; and
- Rated power output.

(c) Endurance Test – Diesel Engine Driven Pump

- The pump set shall be run at the calculated flow rate for 6 hours; and
- At the end of the test the engine speed, the suction and delivery pressure must be recorded at zero, 25%, 50%, 75%, 100% and 110% of the calculated flow rate or at any design flow rate which may be required.

The following hourly records shall be made:

- Ambient temperature;
- The lubricating oil temperature;
- The rise in temperature of the cooling water;
- The cooling water flow rate;
- The engine speed;
- If the engine is fitted with a heat exchanger, the initial temperature and the rise in temperature of the engine closed-circuit cooling water;
- The pump gland temperature;
- Ambient temperature;
- Motor bearing temperatures; and
- Stator temperature.