

JOHANNESBURG WATER (SOC) Ltd.

BULK WASTEWATER

PARTICULAR SPECIFICATION

**E04 : ELECTRICAL LOW VOLTAGE
DISTRIBUTION BOARDS AND MOTOR
CONTROL CENTRES**



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**PARTICULAR SPECIFICATION: VOLUME E04: ELECTRICAL LOW VOLTAGE DISTRIBUTION BOARDS
AND MOTOR CONTROL CENTRES**

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E04.1 INTRODUCTION

This specification is for the supply of low voltage (400V) distribution switchboards.

E04.2 SCOPE

E04.2.1 General

The scope of work includes the furnishing of all labour, material and services for the design, supply, manufacture, testing and inspection at works, delivery to site, off-loading and rectification of defects developing during the warranty period for equipment as specified below.

E04.2.2 Work to be Included

The work includes, but shall not be limited to the items listed below.-

- (a) All work in E04.2.1 above.
- (b) Documentation, as called for in the vendor QA and document requirement list and drawings and data.
- (c) The supply of one complete set of any special tools required per switchboard that will be required for operation or maintenance purposes, including three spare sets of each type of fuse.
- (d) Recommended spares for one year's operating period and the prices of it.
- (e) Technical assistance if requested during checking for operational readiness.

E04.3 STANDARDS

In general, work and materials shall be in accordance with the latest practice and in particular in accordance with the latest revision of the following specifications, and any amendments thereto, the SANS specification taking precedence:

- (a) SANS 10142-1 : The wiring of premises Part 1: Low-voltage installations
- (b) SANS 60439-1 : Low-voltage switchgear and controlgear assemblies Part 1: Type-tested and partially type-tested assemblies
- (c) SANS 60439-2 : Low-voltage switchgear and controlgear assemblies Part 2: Particular requirements for busbar trunking systems (busways)
- (d) SANS 60439-3 : Low-voltage switchgear and controlgear assemblies Part 3: Particular requirements for low-voltage switchgear and controlgear assemblies intended to be installed in places where unskilled persons have access for their use - Distribution boards
- (e) SANS 1973-1 : Low-voltage switchgear and controlgear Assemblies Part 1: Type-tested ASSEMBLIES with stated deviations and a rated short-circuit withstand strength above 10 kA
- (f) SANS 60947-1 : Low-voltage Switchgear and Control gear Part 1: General rules
- (g) SANS 60947-2 : Low-voltage Switchgear and Control gear Part 2: Circuit-breakers
- (h) SANS 60947-3 : Low-voltage Switchgear and Control gear Part 3 Switches, disconnectors, switch-disconnectors and fuse-combination units
- (i) SANS 60947-4.1 : Low-voltage Switchgear and Control gear Part 4-1: Contactors and motor-starters - Electromechanical contactors and motor-starters
- (j) SANS 60947-4.2 : Low-voltage Switchgear and Control gear Part 4-2: Contactors and motor-starters - AC semiconductor motor controllers and starters
- (k) SANS 60947-4-3 : Low-voltage Switchgear and Control gear Part 4-3: Contactors and motor-starters - AC semiconductor controllers and contactors

for non-motor loads

- (l) SANS 60947-5-1 : Low-voltage Switchgear and Control gear Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices
- (m) SANS 62262 : Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)
- (n) SANS 60529 : Degrees of protection provided by enclosures (IP code)
- (o) IEC 60228 : Conductors of insulated cables
- (p) BSS 3858 : Binding and identification sleeves for use on electric cables and wires
- (q) SANS 1507-1 : Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 1: General
- (r) SANS 1507-2 : Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 2: Wiring cables
- (s) SANS 1574-1 : Electric Cables – Flexible Cords and Flexible Cables Part 1: General
- (t) SANS 1574-3 : Electric Cables – Flexible Cords and Flexible Cables Part 3: PVC-insulated cables for industrial use
- (u) SANS 1619 : Small power distribution units (ready-boards) for single-phase 230 V service connections
- (v) SANS 61643-11 : Low-voltage surge protective devices Part 11: Surge protective devices connected to low-voltage power systems - Requirements and test methods
- (w) SANS 61643-12 : Low-voltage surge protective devices Part 12: Surge protective devices connected to low-voltage power distribution systems - Selection and application principles
- (x) SANS 61238-1 : Compression and mechanical connectors for power cables for rated voltages up to 30 kV ($U_m = 36$ kV) Part 1: Test methods and requirements
- (y) SANS 60730-2-7 : Automatic electrical controls for household and similar use Part 2-7: Particular requirements for timers and time switches
- (z) SANS 62053-61 : Electricity metering equipment (a.c.) - Particular requirements Part 61: Power consumption and voltage requirements)
- (aa) BSS 1322 : Aminoplastic Moulding Materials
- (bb) SANS 60076-1 : Power transformers, Part 1: General
- (cc) SANS 1091 : National colour standard
- (dd) SANS 61869-1 : Instrument transformers Part 1: General requirements
- (ee) SANS 61869-2 : Instrument transformers Part 2: Additional requirements for current transformers
- (ff) SANS 61869-3 : Instrument transformers Part 3: Additional requirements for inductive voltage transformers
- (gg) IEC 60051/BS 89 : Direct acting indicating analogue electrical measuring instruments and their accessories. Specification for special requirements for ammeters and voltmeters
- (hh) BS EN 60255 : Measuring relays and protection equipment. Common requirements
- (ii) SANS 156 : Moulded-case circuit-breakers
- (jj) SANS 1195 : Busbars
- (kk) BS159 : High-voltage busbars and busbar connections

E04.3.1 Particular specifications to read in conjunction with this specification

This specification shall be read in conjunction with the following specifications:-

E26: ELECTRICAL COLOUR CODING OF EQUIPMENT

G02: PARTICULAR SPECIFICATION FOR CORROSION PROTECTION

E06: ELECTRICAL MEDIUM AND LOW VOLTAGE CABLE INSTALLATION

E08: WIRING

E04.3.2 Mandatory Requirements

All equipment and services shall comply with the mandatory requirements of:

- (a) Occupational Health and Safety Act 85 of 1993 (as amended).

E04.4 SYSTEM DETAIL

Busbar voltage	400V \pm 10% as per system voltage on the site
Frequency	50 Hz
Phase rotation	R-Y-B-R
Phases	3Ph+N, with Protective Earth (PE)
Earthing system	TN-S

E04.5 GENERAL REQUIREMENTS

This section will be applicable to the following equipment:

- (a) Motor Control Centres (MCC).
- (b) Main Distribution Boards (MDB).
- (c) Auxiliary Distribution Boards (ADB).

The following is described in separate sections:

- (a) Flush Mounted Distribution Boards.
- (b) Surface Mounted Distribution Boards
- (c) LV Kiosks (Switch Cubicles)

E04.5.1 Manufacturing and Construction Details

E04.5.1.1 General

- (a) Electrical panels will be floor standing unless specified differently.
- (b) All floor-standing switchboards will be positioned above a cable trench with bottom entry cables.
- (c) Electrical switchboards positioned inside Electrical Distribution/MCC rooms shall be manufactured with 2mm thick mild steel.
- (d) Electrical switchboards positioned outside Electrical Distribution/MCC rooms shall be manufactured from 2mm thick stainless steel (3CR12) as a minimum. Heaters will be installed in the switchboards to prevent condensation.
- (e) In special applications, the Electrical switchboards will be manufactured to the Engineers specification.

- (f) All switchboards shall be of ample size to accommodate all the specified switchgear and provide space for future switchgear. For every 4 (or part of 4) circuit breakers of a kind on a switchboard, space for an additional circuit breaker of similar size shall be allowed unless future space requirements are clearly specified.
- (g) All specified external dimensions for switchboards shall be strictly adhered to.
- (h) The Contractor or Manufacturer shall obtain the opinion of the Engineer before manufacturing any switchboard.
- (i) The Contractor shall ascertain the exact position of switchboards and shall arrange timeously for the installation of cable sleeves, openings in the structure, flush draw trays behind switchboards and supports over cable trenches.
- (j) In general, flush and surface mounted switchboards shall be mounted 2000mm above finished floor level - measured to the top of the switchboard. The upper ends of switchboards may not be higher than 2100mm above finished floor level.
- (k) Unless otherwise agreed or stated in this Specification, all screws, bolts and nuts shall be hexagonal to ISO metric commercial standards and shall be rustproof. Loose 'bolts and nuts' shall not be used on steelwork. Blind threaded fastening system bushings or equivalent shall be used for thread sizes M5 and above. Studs projecting from the exterior surfaces of the board shall have chrome or cadmium plated dome nuts. Self-tapping screws shall not be utilised for any purpose on any equipment.
- (l) The short-circuit current levels as indicated on drawings shall be deemed the maximum fault current occurring at the panel under symmetrical short circuit conditions on the line side of the final limiting device in a circuit. The duration of the maximum short circuit currents shall be deemed a minimum of one second. Evidence (in the form of certificates from testing authorities recognised by Johannesburg Water) of the ability of the 400V switchboards offered to withstand satisfactorily the prospective fault conditions shall be furnished with the tender.
- (m) Switchboards shall be designed to confine internal arcing faults and to direct arcs and gases arising from these away from the operator.
- (n) The general structure of the panel shall be designed and fabricated to ensure that no excessive vibration caused by the operation of any component is transmitted to any other components, thereby causing spurious tripping of any device.
- (o) Measures shall be taken to prevent electrolytic corrosion where dissimilar metals are in contact with each other.
- (p) Bolts shall be of the correct size for the holes provided and shall be fitted with matching sizes of washers and lock washers. Where removable covers are provided with bolt fastening, the nuts shall be either welded in position or securely fixed by means of a mechanical fixing device. Self-tapping screws, captive head nuts or cage nuts are not acceptable.

E04.5.1.2 Panel Subdivision

- (a) The Electrical panel will be constructed as one or more fully interchangeable modular, rigid, free standing columns, bolted together to form an extensible, composite, vermin proof unit of uniform appearance.
- (b) Panels shall be designed to permit the addition of identical columns.
- (c) Columns widths will be 600, 700, 800, 900 or 1000 mm for design flexibility. Columns will be 600 or 800mm deep. Increase in depth of certain sections of panels for high current ratings shall be subject to the Engineer's approval.
- (d) The overall height of the column may not be more than 2300mm.
- (e) Each column shall be divided horizontally into buckets.
- (f) Panels will be split into transportable section with lengths not exceeding 3000mm for ease of transportation.
- (g) A channel iron frame (minimum 100mm x 50mm) shall be provided under each panel

section of transportable length, which shall be so constructed that it can be used for lifting the transportable section without distortion taking place.

- (h) All panel section of transportable length shall be fitted with lifting lugs and shall have sufficient strength to withstand all stresses occurring during transportation, installation and operation without distortion or damage.

E04.5.1.3 Internal Form of Separation

- (a) The minimum internal Forms of Separation for any Electrical switchboards shall be Form 3b, as described below:
 - i. Separation of busbars from all functional units;
 - ii. Separation of all functional units from one another;
 - iii. Separation of terminals for external conductors from the functional units, but not from those of other functional units;
 - iv. The power cable connections are disposed in the same compartment;
 - v. Maintenance services require extra care, as placed in the same compartment the connections of other units might be powered;

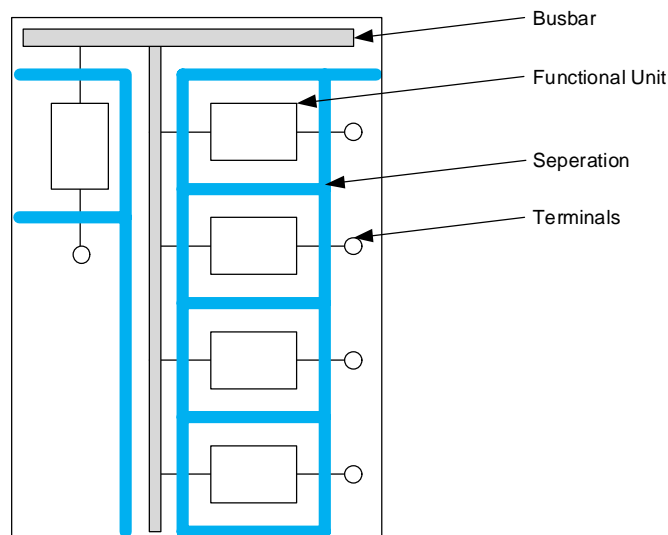


Figure 1: Form 3B

E04.5.1.4 Buckets

- (a) Buckets will be equipped and wired as per the drawings issued by the Engineer.
- (b) The buckets will be sized to accommodate all components with ease.
- (c) Buckets will be fixed pattern with components permanently mounted to the chassis plate of the bucket.
- (d) All bucket design and construction shall be based on natural cooling by convection or radiation. Attention shall be given to ventilation to prevent the accumulation of heat in buckets where power electronic drives (soft starters and VSD's) or other heat generating equipment (i.e. control transformers) are contained. Extraction ventilation fans should be installed in these cases to remove heat from the cubicle. The filtered extraction fan should be placed as high as possible in the compartment door with a filtered air inlet opening as low as possible in the compartment door. The fan and opening must be sized to ensure all generated heat is extracted from the bucket. Natural convection cooling will not be accepted.
- (e) Spare buckets shall be equipped generally as detailed on the drawings issued by the

Engineer, and shall include all circuit breakers, busbars, wiring, instruments, etc., with the exception that, in the case of withdrawable circuit breakers, only the breaker cradle shall be furnished.

E04.5.1.5 Doors

- (a) Buckets shall have doors suitably constructed to ensure rigidity and shall be a neat fit in the framework and around the circuit breaker escutcheon plate.
- (b) Doors shall be fitted with robust steel or brass hinges with at least two 6mm square recessed quick close/open latches. Hinges shall be provided at 500mm intervals per door with a minimum of two hinges per door. Each door shall be fitted with an equal number of hinges and latches. At least one of these latches shall be lockable with a padlock.
- (c) Doors and covers shall be provided with a high-density neoprene gasket to form a firm seal. The neoprene seal shall be a nominal 5mm thick compressed to 3mm on closing of the door. The entire switchboard shall be effectively dust and splash proof to IP 54.
- (d) All hinged doors shall be fitted with a robust mechanism to latch and hold the door in the wide-open position, to minimise inadvertent contact with live parts during maintenance operations.
- (e) All hinged doors shall open to a minimum of 135° from the closed position, to facilitate easy access for maintenance.
- (f) Doors should be the same width as the MCC column. A single door shall not exceed the width of 800mm. Where the column width exceeds 800mm, two doors must be installed.
- (g) The Bucket door shall be interlocked with the circuit breakers to prevent opening of the door when the circuit breaker is in the "ON" position. A non-apparent door interlock defeat shall be provided for the opening of the door with the circuit breaker in the "ON" position for testing and maintenance. In addition, there shall be provision for attaching a padlock to the operating handle in the "OFF" position that prevent the circuit breaker from being operated. Should more than one padlock be fitted, a safety lockout hasp must be used.
- (h) All access doors are to be effectively and permanently earthed to the main panel enclosure, by means of a suitable braided copper earth strap, not less than 6mm², crimped with properly sized lugs and bolted at each end to the door and enclosure.
- (i) All equipment mounted on bucket door will be flush mounted.

E04.5.1.6 Busbar Compartments

- (a) The Busbar compartment shall contain the three phases and the neutral busbars, duly marked L1, L2, L3 and N or identifiable by colour coding Red, White, Blue and Black.
- (b) The protective earth busbar shall be located in a separate compartment, and shall be duly marked PE.
- (c) Provision shall be made for expansion or contraction of the busbars and the housing due to loadings, temperature changes and short circuit conditions. The busbars shall allow for expansion on both the left and right-hand side.
- (d) The busbar compartment shall have bolted covers on the front of the panel for access to the busbars, insulators and joints. Removable covers shall be provided with captive screws.
- (e) All busbars and droppers shall be securely supported by heavy, high di-electric, non-hygroscopic material with bracing to withstand stresses due to short circuits of one second duration and at least equal to the interrupting rating of the circuit breaker protecting the busbars.
- (f) Busbar standoff insulators and support will be injection moulded (Polyamide 66 fibreglass reinforced (30%) (Halogen free)). Threaded inserts will be galvanized steel.
- (g) The Busbar shall be supported by insulators made of flameproof and leakage-proof

material. Busbars, insulators and supports shall be braced to withstand the mechanical and thermal effects of fault currents.

- (h) Busbar insulators shall be mounted in such a way that they can be easily removed and replaced.
- (i) In addition to any support/bracing required by the electrical conditions, the busbars shall also have sufficient support to prevent stresses being transmitted to the circuit breakers or any components by cable terminations. Particular attention must be paid to the termination arrangements of any multiple incoming three-core cables to ensure adequate glanding space.
- (j) The following minimum air clearances shall be observed for busbars and other current carrying or live parts:
 - i. Phase – Earth : 30mm
 - ii. Phase – Phase : 45mm

Where these clearances cannot be attained, suitable insulating barriers shall be employed. In addition, all busbar work (including connections to, from and between equipment) shall have applied solid insulation suitable for the rated voltages. GPO-3 (Glass Polymer laminate) insulation shall be used wherever possible. GPO-3 is constructed with fiberglass-reinforced thermoset polyesters. It must feature a combination of beneficial electrical and mechanical properties. These attributes include Dielectric strength, flame resistance, arc and track resistance, high-flex strength and high-impact strength. They maintain stability, will not melt under heat and have excellent overall electrical properties.

- (k) The busbar compartment shall be constructed to ensure that fire or other faults cannot spread between the various sections. All insulation used on electrical conductors/connections and wiring shall be flame retardant types, constructed of low toxicity materials.
- (l) The busbar compartment must have suitable sealing arrangement at each end as well as between the busbar compartment and buckets.

E04.5.1.7 Cable termination points

- (a) Suitable termination points shall be provided to enable any multiple three-core cables to be terminated without cross-overs of different phases and with minimum lengths of cable "tails".
- (b) All cable termination points and associated connections shall be suitably braced to withstand the available fault currents without damage. If necessary cable support clamps shall be provided for the individual cable tails after the cable gland.

E04.5.1.8 Cable Gland Plates

- (a) Sectionalised removable gland plates shall be fitted and shall be fixed by means of captive nuts or screws and so located that ample space is available for the satisfactory entry and termination of cables
- (b) Cable entry shall be at the bottom of the board.
- (c) All gland plates are to be connected to the main panel earth bar via suitably sized copper conductors and unused sections shall be left blank.
- (d) Gland plates for three-core cable of cross-sectional area 70mm² and above shall be minimum 5mm thickness.
- (e) Mild steel gland plates shall be galvanised.
- (f) Where single core cables are used, gland plates are to be of non-magnetic material or slit to mitigate effect of eddy currents.
- (g) The cable gland compartments shall have removable covers attached with standard 6mm

square recessed quick close/open latches.

E04.5.1.9

Labelling and markings

- (a) The panel shall be provided with an identity label, engraved with 30mm high black on white characters and shall be mounted on top of the switchgear.
- (b) Each buckets shall be labelled on the left top door corner with the reference letter(s) of that compartment, using durable designation label with 30mm high black letters on a white background. The labels shall have two designation letters, the first referring the column, numbered from A, left to right and the second referring to the bucket, numbered from 1 top to bottom.
- (c) All buckets shall be clearly labelled with suitable inscriptions indicating their function. All labels shall have black characters at least 6mm high on white background.
- (d) Incomers shall be labelled "Incomer from" as indicated on the drawings issued by the Engineer, using engraved black characters at least 6mm high on white background.
- (e) Standby bus coupler (where applicable) shall be labelled "Standby Bus Coupler", using engraved black characters at least 6mm high on white background.
- (f) All removable covers protecting live equipment shall be fitted with warning labels as well as ID tags to ensure the covers are replaced in the original position after removal. Warning labels shall be engraved white characters 6mm high on a red background.
- (g) All electrical components/equipment shall be labelled (with designations corresponding to those of the Engineer's schematic diagrams) to facilitate recognition.
- (h) The labels for equipment mounted on doors shall be identified with white trifoliate labels having black lettering engraved on them, with a maximum height of 3mm letters.
- (i) The equipment labels shall be secured by means of high quality double-sided tape.
- (j) The labels for all equipment, installed behind panels, shall be fixed to the chassis close to the equipment.
- (k) If this equipment is positioned too close to each other to accommodate descriptive engraved labels, the equipment may be identified by a code or number label, which shall be fixed close to the equipment. The code or number shall be identified on a legend board, which shall be installed on the switchboard behind a protective cover.
- (l) The types of labels for equipment behind the doors or covers shall be subject to the Engineer's approval.
- (m) Danger labels shall be white lettering 6mm high engraved on a red background.
- (n) All labels and label brackets shall be affixed by machine screws. Adhesive labels are not acceptable.
- (o) Over and above labelling requirements of this specification, the labelling requirements of SANS 10142-1 must be met.

E04.5.1.10

Insulation Materials

- (a) Any insulation, filling putty, etc., used shall be selected such that it can withstand without harmful effect (mechanically or electrically), all temperatures encountered within the MCC.

E04.5.2

Electrical Details

E04.5.2.1

Busbars and Connections

- (a) Busbars and connections shall generally comply with SANS 1195 for air clearances. Notwithstanding the contents of the above-mentioned specifications, all solid copper work shall be made of hard drawn high conductivity copper of constant cross-section throughout

their lengths with a maximum design current density of 1,66A/mm².

- (b) The Phase and Neutral busbars shall be manufactured with flat copper bars with a standard rectangular conductor profile, of the same cross-section over the whole width of the panel.
- (c) Busbar droppers shall be manufactured with flat copper bars with a standard rectangular conductor profile, of the same cross-section over the whole length of the dropper. The use of flexible conductors as droppers from the main busbars to circuit breakers shall not be permitted.
- (d) All busbar joints shall be silver plated or tinplated. High pressure bolted lap joints shall be used and all bolts shall be of the high tensile type.
- (e) All fixed busbar joints (separation links) between adjacent sections shall be maintenance-free.

E04.5.2.2 Earth Bar

- (a) A protective earth bar shall extend the whole length of each Electrical panel and shall be duly marked PE. The earth bar shall at least, be bolted to the switchgear housing at each column.
- (b) Stranded clear insulated aluminium earth wire (equal to 70mm² copper wire) with crimp type terminals shall be provided at both ends of the protective earth bar for connection to the substation earth bar/earthing system.

E04.5.2.3 Control Wiring

- (a) Each Electrical panel shall be equipped and completely wired at the factory and, only after satisfactory testing, be split, if necessary, for transportation.
- (b) Control and instrumentation wiring shall be silicone insulated throughout and of flexible, stranded, annealed, untinned copper construction. All wiring shall comply with the table below. Conductors shall comply with SANS 1411, Part 1, Table 4, Class 5.

CT Wiring	- 2.5mm ² phase coloured, common return black insulated, earth green/yellow
General Control Wiring	- (AC) 1.0mm ² grey
	- (DC) 2.5mm ² (positive – red, negative – black)
Control Neutral	- (AC) 1.0mm ² (same size as phase wiring) – black
LED's and PLC Inputs	- (AC) 0.75mm ² grey
	- (DC) 0.75mm ² (positive – red, negative – black)

- (c) Notwithstanding the above-mentioned requirements, the vendor shall ensure wire size used is amply rated for the applicable current, under ambient conditions.
- (d) All control/instrument panel wiring shall terminate by means of suitably sized compression crimp lugs on screw-type terminals. Terminals of the pressure pad type are not accepted. The minimum voltage rating of the control wiring shall be 600/1000V grade to SANS 1507 and SANS 1411 Parts 1 and 3.
- (e) Wiring shall be run in plastic trunking. Only where a space problem exists will loomed wiring be acceptable.

Note: Stick-on harness holders are not acceptable.

- (f) Conductors passing through holes in compartments shall be protected by means of neoprene grommets. Bevelling of sheet steel will not be accepted as a substitute.
- (g) Conductors shall be general-purpose 600/1000V grade PVC-insulated copper wire to SANS 1507 and SANS 1574. Aluminium conductors are not acceptable.
- (h) Single or solid conductor wire shall not be used.
- (i) Joints or splices in any wiring are not acceptable.
- (j) Panel and equipment terminals, labels, etc., shall be accessible after the wiring has been completed.
- (k) Connections to equipment on swing doors shall be arranged to give a twisting motion and not a bending motion to the conductor.
- (l) Single pole and double pole moulded-case circuit breakers shall be wired in a way that the supply to the switchboard is equally balanced.
- (m) Stripping of insulation shall not result in damage to the conductors. The stripping tools used shall be of the type, which permits the length of strip to be pre-set. Control wiring shall be terminated with pre-insulated, crimped or compression type lugs. Crimping tools shall be of the type, which will not release the termination during normal operation until the conductor crimp has been correctly formed. Any damaged wiring will be rejected.
- (n) Lugs shall be of the hooked blade type when used in conjunction with screw clamp spring loaded insertion type terminals, ring tongue type when used with stud or direct screw mounted connections and wire pin when used with pinch screw type connections such as indicating lamp fittings.
- (o) Not more than two conductors shall be connected to any side of a terminal.
- (p) Each terminal strip shall be provided with not less than 10% spare terminals, with a minimum of two, unless otherwise approved.

E04.5.2.4 Power Wiring and Cable Terminations

- (a) Power wiring on the "live" side of the circuit breakers (from the busbar dropper to the circuit breaker terminals) shall be as short as possible, sized to carry the maximum current continuously of the frame size of the respective circuit breaker and shall be a flexible copper conductor. The flexible connection shall be provided on all such connections and shall be designed to prevent the transmission of any forces that may arise between the busbar droppers and the circuit breaker. In terms of SANS 60439, this connection is deemed a fault free zone and the design and use of the flexibles shall in no manner compromise this zone.
- (b) Power wiring on the "load" side of the circuit breaker terminals to cable termination terminal shall be as short as possible, sized to carry the maximum current continuously of the frame size of the respective breaker and shall be a flexible conductor. The flexible connection shall be provided on all such connections and shall be designed to prevent the transmission of any forces that may arise between the circuit breaker and the cable termination terminal. In terms of SANS 60439, this connection is deemed a fault free zone and the design and use of the flexibles shall in no manner compromise this zone.
- (c) Terminals that are on the live side of fuses and isolating switches shall be completely shrouded to prevent accidental contact.
- (d) Power circuit wiring and connections in a switchboard shall be rated to the full frame size rating of the associated equipment, i.e. fused switch, contactor, circuit breaker, etc., and not to the circuit or fuse rating.
- (e) Power wires shall bear the colour along their entire length of the phase to which they are connected.
- (f) Neutral connections shall have the same rating as the phase connections unless otherwise

approved.

- (g) Power wiring terminations shall use an appropriate crimped accessory (the pressed tubular type of accessories). Stamped, folded, split-barrel type accessories are not acceptable.
- (h) Terminations for power wiring and cabling shall be provided with pressure type clamping connections or bolted connections capable of accepting crimped or compression type lugs on conductors.
- (i) In addition, hexagonal die type hydraulic crimping shall be used for all wiring greater than 16mm² in size.
- (j) Cables shall be made off directly onto circuit breakers, switches, contractors, thermal-overloads, etc. Terminals or solid copper terminating conductors shall be provided where necessary. Provision shall be made for bracing and fixing of the cable leads to prevent vibration.
- (k) A predrilled solid copper bar shall be provided for terminating all external power cables above 70mm, or where three or more cables in parallel are specified. The arrangement shall be suitable for accepting cable lugs of conductors up to 630mm².

E04.5.2.5 Wire Numbering

- (a) Each end of every wire shall be marked with a wire number by means of plastic cable ferrules (black lettering on a white or yellow base).
- (b) All wires shall be identified on both ends with a wire marker. The wire marker shall consist of a transparent flexible tube that slides over the wire with a wire identification label (black letters on a rigid white PVC tag) which slides into a label pocket on the tube. The tube must be correctly sized for the wire diameter.
- (c) Split or open type marking ferrules shall not be used.
- (d) Cable/wire marking ferrules shall correlate to the appropriate schematic or wiring diagrams.
- (e) For all control wires without lug terminations, the numbered ferrule must not fall off when disconnecting the wire and in this regard, the use of one strand of wire to retain the ferrule is acceptable.
- (f) All cables shall be identified on both ends with a cable marker. The cable marker shall consist of printed stainless steel band fixed to the cable with stainless steel strapping.

E04.5.2.6 Terminals and Connections

- (a) All terminals will be of the screw-type. Terminals of the pressure pad type are not accepted. Minimum rating for terminal blocks shall be 40A. Terminal strips/blocks shall be marked with designations corresponding with the suppliers/buyers drawings. Generally, terminal numbers shall be the same as the relevant wire number. No more than two wires may be connected to any one side of a terminal. Ten percent (10%) additional spare terminals shall be furnished.
- (b) Terminals are to be provided for all door-mounted components, diodes, etc.
- (c) Power connections on any equipment shall not use "Philips/Star" type screw/socket heads. Hexagon socket head cap screws (Allen type socket heads) are preferred.
- (d) Where a large number of control terminals are mounted in close proximity, the terminals shall be in vertical rows with a minimum of 125mm below rows. Spare terminals shall be mounted at the bottom of the row unless the cabling drawing shows otherwise.
- (e) Terminals shall be provided for all cores of external control cable as indicated on the drawings whether internally connected or not.

E04.5.2.7 Air Circuit Breakers (ACBs)

- (a) ACBs shall be of the withdrawable type with self-aligning disconnecting devices with the disconnecting fingers preferably mounted on the breaker for ease of maintenance. The draw out mechanism shall hold the circuit breaker rigidly in the fully connected, test and fully disconnected positions.
- (b) Safety shutters shall be provided to shield the fixed part automatically when the draw out parts removed preventing access to the conductors (main and auxiliary circuits). These shutters shall be clearly labelled indicating busbar and cable sections and in addition "live" section shall be labelled "400V – LIVE". ACBs shall be equipped with inter-phase barriers.
- (c) Each Incoming ACB from a transformer and each Bus Section ACB shall be equipped with a protection unit incorporating:
 - i. Overload protection (IDMT)
 - ii. Thermal overload protection
 - iii. Instantaneous short-circuit protection

All protection devices will be delivered with protection settings adjusted to the minimum level. The protection unit shall be fitted with a transparent cover that can be sealed in the closed position to prevent tampering with the settings.

- (d) The Contractor shall take particular care to ensure that the ACB protection is correctly co-ordinated with the upstream and downstream protective devices.
- (e) Current and time delay set points on ACBs shall be accessible from the front of the ACB without removing the ACB from its cradle and shall only be adjustable when the cubicle door is open.
- (f) Interlocks shall be provided to ensure the following:
 - i. That the main circuit breaker cannot be removed from or to the fully connected position unless the ACB is open;
 - ii. That the compartment doors cannot be opened should any accessible portion of the ACB frame be energised;
 - iii. That the ACB cannot be closed unless in the fully connected, test or fully disconnected positions.
- (g) Mechanical restrictions shall be provided to inhibit mismatch of ACBs of different ratings.
- (h) Provision shall be made for the padlocking of any ACB in any one of the fully connected, test or fully open positions. In addition, all ACBs shall have padlocking facility to prevent the close push button being operated when padlocked.
- (i) ACBs employed as incomers and bus-section switches shall incorporate captive key interlocks to prevent paralleling of incoming supplies. Locks with captive keys must be built into the ACB's to prevent both Incomers and the Bus-coupler circuit breakers in the "ON" position at the same time. Padlocks will not be accepted for this application.
- (j) The ACBs supplied shall be three pole, magnetic operated. The mechanism shall be of the stored energy type having hand charged spring with mechanical and electrical releases for closing.

E04.5.2.8 Moulded Case Circuit Breakers (MCCBs)

- (a) MCCBs shall be of the manually operated type with thermal and instantaneous magnetic protection. Trip functions shall be resettable via the MCCB switching handle.
- (b) Each MCCB shall be fitted with a vari-depth operating handle.
- (c) Flash barriers shall be furnished to increase creepage distance between phases and shall be furnished on all circuit breaker cradles between the phases on both sides of the MCCB.
- (d) The thermal trip elements of each MCCB shall be calibrated for the maximum ambient

temperature at 40°C.

- (e) Current ratings of MCCBs shall be detailed in the Single Line Diagram drawings.
- (f) MCCBs shall be selected according to rating and the fault level as specified by the Engineer.
- (g) The name of the MCCB manufacturer shall be furnished by the tenderer at tender stage.
- (h) Each MCCB shall be provided with suitable insulation between the terminals of the MCCB and the back plate/chassis onto which the MCCB is mounted, such that any loose nut, screw, etc., which may fall between the MCCB terminals and back plate cannot cause a short circuit.
- (i) Where interlocking is called for between the MCCBs this shall be effected using captive keys in the breaker or a mechanical interlock.
- (j) All outgoing circuits shall be equipped with individual core balance earth leakage units arranged to shunt trip each respective outgoing circuit.
- (k) Outgoing circuits rated 125A and above shall have IDMT 375 mA earth leakage units EPC type Elsec T. Outgoing circuits rated 100A and below shall have instantaneous 250 mA earth leakage units - EPC type Elsec – X. All earth leakages must be of the manual reset type.
- (l) All circuit breakers, except bus couplers, shall be connected with the switched side to the load, i.e. with reference to power flow incoming to "LINE" and outgoing to "LOAD".
- (m) The incoming terminals/shutters of all 400V circuit breakers shall be effectively shrouded and marked "400V LIVE" with white characters on a red ground.

E04.5.2.9 Miniature circuit breakers (MCBs)

- (a) Miniature circuit breakers (MCBs) shall be confined to auxiliary circuits such as control and indication in which the prospective short-circuit current will not exceed 5kA (3ph at 440Vac), or 7.5kA (1p at 24Vdc). They shall be of the thermal and magnetic trip free type. Where the prospective short-circuit current exceeds the above values, cascaded circuit breakers should be used. All cascaded circuits must be marked with the wording "Warning: This is a cascaded system. Never replace any circuit breaker in the system with another circuit breaker that is not identical in manufacturer, type and rating."
- (b) Auxiliary contacts on MCBs
 - i. Provide the position (open/closed/tripped) remote indication functions of the associated MCB.
 - ii. Clip on (no tool required) to the left-hand side of the MCB. The type that connects to the MCB operating lever is preferred.
 - iii. Shall be of good quality and will not interfere with the operation or tripping of the MCB.

E04.5.2.10 Surge Arrestors

- (a) All Electrical switchboards shall have a surge arrestor fitted to each phase on the incoming circuit breaker. The surge arrestors shall be fitted to the LIVE side of the circuit breaker.

E04.5.2.11 Instruments and Meters

- (a) Incoming CBs shall be equipped with the following as a minimum requirement:
 - i. A single 96mm x 96mm 5A secondary, combined maximum demand and instantaneous ammeter. The maximum demand portion shall have a thermal movement with 15-minute time lag and drag pointer having a reset facility. It shall have a built-in saturation transformer for increased overload capacity to 90 times

rated current for one second;

- ii. A 96mm x 96mm voltmeter connected to measure phase-to-phase voltage and phase to neutral voltage via a multi-position selector switch and a set of fuses suitably rated for voltage and short circuit current;

E04.5.2.12 Current Transformers

- (a) All current transformers shall conform to SANS 61869-2. For protection purposes, class 10P CT's are to be used and for indicating purposes class 1 CT's are to be used and for metering purposes class 0.5 CT's are to be used. In general, current transformer mechanical and thermal ratings shall be co-ordinated with the short circuit ratings of the equipment.

E04.5.2.13 Fuses

- (a) Fuse protection shall be used in cases where capacitive loads are switched i.e. Power factor correction or static capacitors panels.
- (b) Fuses shall not be used for purposes other than voltmeter or kWh meter protection, unless specifically authorised. All short circuit protection shall be provided by means of circuit breakers and fast blow fuses for protecting the incoming side of the devices. In cases where the fault current level is excessively high, HRC fuses in conjunction with CB's should be considered to reduce the fault level and afford better protection for electrical personnel.

E04.5.2.14 Limit Switches

- (a) Limit switches shall be metal encapsulated precision switches with robust and compact explosion-proof structures.
- (b) Cables shall be equipped with a strain-relief device and safely cast into the enclosure. Switches shall have bottom, side or lateral cable outlets as per the requirement of the application. The integrated basic switch shall have a single-pole changeover contact with a high switching accuracy and a precise repeatability of the switching point.
- (c) It shall have high vibration resistance and long mechanical life. It shall have a high protection class that would allow the switch to be used in all processes of Johannesburg Water wastewater treatment plants.

E04.5.3 Mounting of Equipment

E04.5.3.1 Clearance and Access

- (a) A minimum clearance of 50mm shall be maintained between items of equipment and the side of the compartment.
- (b) Where extra equipment is specified after the design has been finalised, this clearance requirement may be altered subject to the Engineer's approval.
- (c) No piece of equipment shall be mounted in any position where it is not visible and accessible to a viewer looking into the compartment through the door opening.

E04.5.3.2 Mounting of Circuit Breakers

- (a) All moulded case circuit breakers shall be flush mounted with only toggles protruding.
- (b) Miniature circuit breakers may be installed in clip-in trays mounted on the frame.
- (c) Special provision shall be made for large main switches.
- (d) Circuit breakers shall be installed so that the toggles are in the up position when "ON" and down when "OFF".

E04.5.3.3 Mounting of Contactors

- (a) Contactors shall only protrude through the panel in special cases. Plastic covers or other coverings will not be required.

E04.5.3.4 Instrumentation

- (a) All metering instruments shall be mounted flush in the front panel unless otherwise specified.
- (b) In certain instances it may be required that instruments be mounted flush in the door. In these instances, the back of metres shall be covered by removable covers of isolating material fixed to the door to protect the terminals of instruments and to prevent accidental contact.
- (c) Equipment mounted normally on the surface, e.g. time switches and relays shall be mounted behind the front panel. In these cases, hinged access panels shall be provided in the front panel.

E04.5.3.5 Fuse-Links and Carriers

- (a) Fuses shall be of the high rupturing capacity type and shall be mounted on insulated draw-out carriers, which shall hold the fuses positively and remain firmly fixed after withdrawal. In all cases, the top terminal shall be the live terminal. This applies also for MCB's.
- (b) DC circuits shall have fuses in the positive and negative leads.
- (c) Fuses shall be so positioned that they are readily accessible to a person standing on the floor.
- (d) Fuses for instrumentation shall be mounted on the outside of the compartment door adjacent to or below the instrument.
- (e) Fuses shall be provided with labels giving their rating and duty.
- (f) Solid link holders shall be coloured white.
- (g) One spare fuse of each type and size used in each board shall be fitted on clip holders on the inside of the front panel.

E04.5.3.6 Control Equipment

- (a) All equipment performing control functions, e.g. control relays, transducers, and time relays not requiring adjustment, shall be mounted behind the front panel.

E04.5.3.7 Current Transformers

- (a) Current transformers shall be accessible and easily removable.
- (b) Secondary windings of current transformers shall be earthed at one point only. Each group of current transformers, i.e. protection, metering, etc., shall be earthed directly to the protective conductor (earth bar).
- (c) Current transformers shall be naturally air-cooled, and shall be able to withstand the maximum fault current for the duration of time taken by the functional unit to clear, with protective devices set at the maximum time delay settings.

E04.6 MOTOR CONTROL CENTRE

A Motor Control Centre (MCC) is an assembly of one or more enclosed sections having a common

power bus and principally containing motor control units that serves to govern in some predetermined manner the performance of an electric motor. Motor control centres are in modern practice a factory assembly of several motor starters. A motor control centre can include variable frequency drives, programmable controllers, metering apparatus etc. Motor Control Centre is used for controlling of various motors of a particular plant.

E04.6.1 MCC Buckets

- (a) The following types of motor starters will be used:
 - i. Direct-on-line (DOL) type motor starting;
 - ii. Star/Delta (S/D) type motor starting;
 - iii. Forward/Reverse type motor starting;
 - iv. Soft starting (SS) type motor starting;
 - v. Variable Speed Drive (VSD) type motor starting.
- (b) The main contactors on Star/Delta and Forward/Reverse type starters will be mechanically interlocked. The type of motor starting required shall be project specific and shall be indicated in the MCC schedule/s to be issued by the Engineer.
- (c) All the protection devices, i.e. overloads, circuit breakers, motor thermistors, motor heaters, gearbox oil flow switches etc. on mechanical equipment shall be hard wired onto the individual motor starter circuits.
- (d) Only one motor will be controlled from any MCC bucket.

E04.6.2 Busbars

- (a) Main busbars in MCCs shall be rated for 2000 amps as a minimum.
- (b) Busbar droppers in MCCs shall be rated for the maximum possible current (determined by the breaker frame size) in that section with a minimum rating of 1000 amps.

E04.6.3 Earth bar

- (a) The earth bar shall be rectangular, with a minimum cross sectional area of 400mm² (10mm x 40mm).

E04.6.4 Power wiring

- (a) The minimum MCC power wiring size shall be 25mm².

E04.6.5 Circuit Breakers

- (a) Air circuit breaker (ACBs) will be used for Incomer circuit breakers on MCCs.
- (b) Bus coupler circuit breakers on MCCs will use an air circuit breaker (ACBs).
- (c) Moulded Case circuit breakers (MCCBs) will be used for outgoing feeders on MCCs up to a maximum rating of 800 amps.

E04.6.6 Instruments and Meters

- (a) Incoming CBs shall be equipped with an power meter capable of providing multiple parameters of the connection including kWh, kVARh, kW, kVAR, PF, MD, etc. and provide a pulsed output and Ethernet connectivity.
- (b) Each bucket shall be equipped with a suitably sized 5A current transformer (CT) operated

96mm x 96mm 90° movement suppressed maximum demand ammeter having an overload rating of 40 times the rated current for one second. The CT primary current rating will match (equal) the outgoing feeder circuit breaker current rating. The CT secondary current rating will be 5A.

E04.7 MAIN DISTRIBUTION BOARD

A Main Distribution Board is a panel from where electrical energy is taken out to distribute power to various consumer points. It has a single incoming power sources from a distribution transformer and includes feeder circuit breakers and protection devices to the consumers.

E04.7.1 Busbars

- (a) Main busbars in MDBs shall be rated for 2000 amps as a minimum.
- (b) Busbar droppers in MDBs shall be rated for the maximum possible current (determined by the breaker frame size) in that section with a minimum rating of 1000 amps.

E04.7.2 Earth bar

- (a) The earth bar shall be rectangular, with a minimum cross sectional area of 400mm² (10mm x 40mm).

E04.7.3 Power wiring

- (a) The minimum MDB power wiring size shall be 25mm².

E04.7.4 Circuit Breakers

- (a) Air circuit breakers (ACBs) shall be used as Incomer circuit breakers on MDBs.
- (b) Moulded Case circuit breakers (MCCBs) will be used for outgoing feeders on MDBs up to a maximum rating of 800 amps.

E04.7.5 Instruments and Meters

- (a) Incoming CBs shall be equipped with an power meter capable of providing multiple parameters of the connection including kWh, kVArh, kW, kVA, PF, MD, etc. and provide a pulsed output and Ethernet connectivity.
- (b) Feeder CBs shall be equipped with an power meter capable of providing multiple parameters of the connection including kWh, kVArh, kW, kVA, PF, MD, etc. and provide a pulsed output and Ethernet connectivity.

E04.8 AUXILIARY DISTRIBUTION BOARD

An Auxiliary Distribution Board is a panel from where electrical energy is taken out to distribute power to various consumer points. It has a single incoming power sources from a Main Distribution Board and includes feeder circuit breakers and protection devices to the consumers.

E04.8.1 Busbars

- (a) Main busbars in ADBs shall be rated for 1000 amps as a minimum unless otherwise specified/approved by the engineer.
- (b) Busbar droppers in ADBs shall be rated for the maximum possible current (determined by

the breaker frame size) in that section with a minimum rating of 600 amps unless otherwise specified/approved by the engineer.

E04.8.2 Earth bar

- (a) The earth bar shall be rectangular, with a minimum cross sectional area of 250mm² (10mm x 25mm) unless otherwise specified/approved by the engineer.

E04.8.3 Power wiring

- (a) The minimum ADB power wiring size shall be 16mm² unless otherwise specified/approved by the engineer.

E04.8.4 Circuit Breakers

- (a) Air circuit breakers (ACBs) shall be used as Incomer circuit breakers on ADBs unless otherwise specified/approved by the engineer.
- (b) Moulded Case circuit breakers (MCCBs) will be used for outgoing feeders on ADBs up to a maximum rating of 800 amps.

E04.8.5 Instruments and Meters

- (a) Incoming CBs shall be equipped with an power meter capable of providing multiple parameters of the connection including kWh, kVArh, kW, kVA, PF, MD, etc. and provide a pulsed output and Ethernet connectivity.
- (b) Feeder CBs shall be equipped with a suitably sized 5A current transformer operated 96mm x 96mm 90° movement suppressed maximum demand ammeter having an overload rating of 40 times the rated current for one second. The CT primary current rating will match (equal) the outgoing feeder circuit breaker current rating. The CT secondary current rating will be 5A.

E04.9 FLUSH MOUNTED DISTRIBUTION BOARD

E04.9.1 Internal for of Separation

- (a) The internal for of separation will be specified by the Engineer.

E04.9.2 Bonding Tray

- (a) Bonding trays for flush mounted switchboards shall be of rigidly constructed 1,6mm thick galvanised steel, braced and reinforced.
- (b) Formed gussets shall be provided at the corners. All the tray joints shall be properly welded or securely bolted with a brass or cadmium plated steel earth connecting stud and nut.

E04.9.3 Expanded Metal

- (a) Where switchboards are to be built into 116mm thick walls, expanded metal shall be spot welded to the rear of the bonding trays.
- (b) The expanded metal shall protrude at least 150mm on each side to prevent plaster from cracking.

E04.9.4 Knock-Outs

- (a) Ample knockouts 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.
- (b) Knockouts shall be allowed for any size of specified conduit.
- (c) Provision shall however be made for termination of at least 2 x 25mm diameter conduits at top and 2 x 25mm diameter conduits at the bottom of each tray.

E04.9.5 Architrave Frame

- (a) The architrave frame shall be of 2,0mm thick sheet steel with bevelled edges.
- (b) The architrave frame shall accommodate the chassis, panels and doors.
- (c) The architrave shall overlap the bonding tray by at least 25mm on each side.
- (d) The architrave frame shall be fixed to the tray in such a fashion to allow for depth adjustment and irregularities of the wall.

E04.9.6 Extension Frames

- (a) Semi-flush mounted switchboards shall be equipped with extension frames.
- (b) Generally, the frame depths shall be 50mm but may be altered to suit each application.

E04.9.7 Chassis

- (a) The chassis for mounting of switchgear and equipment 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.
- (b) The chassis position shall be adjustable in the horizontal plane.

E04.9.8 Panel (Faceplate)

- (a) A suitably stiffened panel manufactured of 2,0mm thick sheet steel shall be installed in the architrave frame for flush mounting of switchgear.
- (b) The panels shall have machined punched slots for housing the specified and future switchgear, instruments, fuse holders, isolating switches, indicator lamps, etc. In exceptional cases, contractors will be allowed to protrude through the panel.
- (c) Blanking plates shall be provided in positions where future switchgear will be installed.
- (d) The distance between the inside of the closed doors and the panels shall be not less than 40mm.
- (e) No equipment may be mounted on the panel (faceplate) unless it is permanently hinged to the switchboard frame.

E04.9.9 Fixing of Panels

- (a) The panel for each switchboard shall be secured to the architrave frame by means of captive fasteners. 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 panel. Self-tapping screws or dome nuts will not be allowed.
- (b) Where it is required that equipment be mounted on the panel, the panel shall be securely hinged to the switchboard frame.

E04.9.10 Panel Handles

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

E04.9.11 Hinged Panels

- (a) Where hinged panels are specified, the hinges shall be fixed to the architrave frame and the panel shall be secured by means of studs and hexagonal chromium plated nuts or by means of a suitable lock or latch, which can be operated with a screwdriver.
- (b) The panel shall be removable when it is in the open position.

E04.10 **SURFACE MOUNTED DISTRIBUTION BOARD**

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

E04.10.1 Internal for of Separation

- (a) The internal for of separation will be specified by the Engineer.

E04.10.2 Switchboard Tray

- (a) Surface mounted switchboards shall be equipped with a 1,6mm sheet steel reinforced tray.
- (b) Securing lugs shall be provided to fix the tray to walls or any other structure.
- (c) A solid brass or cadmium plated steel earth connection stud and nut shall be provided.

E04.10.3 Construction

- (a) All joints shall be welded or securely bolted.
- (b) The tray shall be square and neatly finished without protrusions.
- (c) The front tray sides shall be rounded with an edge of at least 20mm to accommodate flush doors.
- (d) The requirements for chassis, panels and doors shall be as specified for flush mounted switchboards.
- (e) The doors shall be hinged and shall fit flush in the frame in the closed position.
- (f) Knockouts shall not be provided unless specifically called for.

E04.11 **LV KIOSKS (SWITCH CUBICLES)**

LV kiosks shall be of sufficient size to accommodate all the specified equipment.

E04.11.1 Framework

LV kiosks shall be manufactured of mild steel sheet metal with a minimum thickness of 2mm or cold rolled 3CR12 sheet metal with a minimum thickness of 1,6mm. Fibre re-inforced or other corrosion proof material (e.g. glass fibre) may also be used if adequately reinforced.

E04.11.2 Ventilation

Two ventilation slots or grilles, approximately 150 x 125mm and covered on the inside with copper mesh, shall be provided on opposite sides of the cubicle.

E04.11.3 Doors

Doors shall be provided in the front and back panels and shall swivel through 180°. Rigid padlocks and base plates for security latches shall be provided on the doors. Openings for security latches shall be blanked with chromed brass discs.

E04.11.4 Warning Sign

Warning and danger signs shall be mounted on each door in compliance with the requirements.

E04.11.5 Base

The kiosk shall be mounted on a well-finished concrete base, with minimum height of 150mm above ground level in the case of mild steel and any of the other specified acceptable materials. The kiosk can be made for direct mounting into the ground in which case it shall be equipped with a base, forming part of the structure, for this purpose. The switch cubicle shall protrude at least 10mm past the edges of the base to prevent water collecting on the base.

E04.12 **STANDBY SUPPLIES**

- (a) Where standby power from a diesel-generator set or other source is available and has to be connected to some of the equipment on a panel, the panel shall be divided into electrically separate sections with sheet metal division plates to isolate power and mains power sections. The section doors must be appropriately colour coded to provide visual distinguishing.
- (b) A means shall be provided to isolate both the standby and mains power supplies simultaneously. For this purpose, either a 6-pole rotary switch or mechanically and electrically interlocked circuit breakers or contactors may be used. Electrical interlocking alone is not sufficient. Rotary switches may only be used on panels where the fault level does not exceed 10kA.
- (c) A separate 3-pole circuit breaker shall be provided as main switch for both the standby power section and the mains power section in addition to the isolator of (b) above.

Where a 6-pole rotary switch is used as isolator for the incoming supplies, this switch may be located in the standby section of the switchboard in which case the rotary switch can also serve as the isolator for the standby section. This arrangement is acceptable where the equipment on the mains power section of the switchboard can be turned off whenever it is necessary to work on the standby section of the switchboards.
- (d) The main switches to the standby and mains power sections shall be interlocked with the doors providing access to those sections to ensure that the door can only be opened when the switches are in the OFF position.

E04.13 **ELECTRICAL SUBSTATION FIRE PROTECTION SYSTEM**

It is the duty of the Contractor to appoint a trained and competent fire engineering company to design, supply, install, commission, and test and certify a fire protection system for each electrical substation building forming part of the contract.

Each fire protection system will consist out of a fire detection and an extinguishing system as described below. Both systems will be of the highest quality and latest technology, supplied by a reputable manufacturer. The contractor will submit written proof that local support is available to maintain the system and to supply spare parts as required.

E04.13.1 Fire Detection System

The fire detection system must:

- (a) Utilise a sub-micron combustion particle detector that detects a fire at its initial stage, before the presence of smoke. This allows preventative action can be taken before any catastrophic event occurs.
- (b) Utilise detectors suitable for dusty plant environments and must be impervious to false alarms caused by dust particles in substation buildings with sheet metal roofs where no ceilings are present.
- (c) Cover the substation building, all electrical cabinets and all cable trenches.
- (d) Only when there is a second alarm from a second detector the system will trigger the gas.
- (e) Double Knock system (Trigger an alarm on the first detector activation and trigger the operation of a fire extinguishing system on a second detector activation).
- (f) Alert a control and alarm signalling system in case of a fire or a system fault.
- (g) Be designed and installed to conform to SANS/ISO 10139 and SANS 369 Parts 1 and 2.

E04.13.2 Fire Extinguishing System

The fire extinguishing system must:

- (a) Utilise an automatic system to flood the substation building with a concentration of a gaseous extinguishing agent to extinguishing a fire burning in Class A, B, and C hazards by lowering the oxygen content below the level that supports combustion as quickly as possible.
- (b) Utilise a non-toxic, human friendly extinguishing agent. The use of an extinguishing agent that does not support human life must be approved in writing by the Engineer. In this case, other safety measures such as a lockout system should be integrated to ensure safe entrance into the protected substation.
- (c) Utilise an efficient extinguishing agent that is electrically non-conductive and that will not adversely affect the protected electrical equipment. No powder or other residue should remain after actuation of the system.
- (d) Audible and visual warnings must alert personnel to vacate the protected substation area before discharging the agent.
- (e) Utilise a colourless, odourless environment friendly extinguishing agent that is sustainable against impending global warming regulations.
- (f) Utilise an extinguishing agent that has a low refill cost.
- (g) Should be fully approved by the local authority to an internationally accepted engineering standard.

E04.13.3 Other measures

- (a) All points where cable or other services enter the substation building must be properly sealed with a fire rated medium of at least one-hour or as per local standards and regulations.
- (b) All ventilation and air conditioning devices must be tripped in the event of first detection of a fire.
- (c) All ventilation openings and doors in the substation building should be sealed in the event of first detection of a fire.
- (d) A room integrity test needs to be carried out to validate the hold-time for the extinguishing agent as per the room's natural leakage.

- (e) All detection, alarm and extinguishing circuits are to be monitored for system faults.
- (f) The substation fire protection system should operate a local audible and visual alarm system and report to a central 24-hour manned operations or security room.
- (g) A local handheld fire extinguisher should also be installed within the substation as per local regulations. The type and number should conform to local standards and regulations.

E04.13.4 System Maintenance

- (a) The contractor will include a fire protection system maintenance contract for a period of one year after commissioning. A trained and competent fire engineering company must do the maintenance.
- (b) Thereafter a trained and competent fire engineering company should be contracted to inspect the system on a three-month basis. It should check that the system is operational in terms of its design and take corrective action in the event of a fault.
- (c) The Client should visually check the system once a month for any faults reported on the control panel and anything that might appear out of the ordinary. The Client should immediately report to a competent fire engineering contracting company of any concerns or faults to ensure immediate rectification.
- (d) A mandatory annual room integrity test should be carried out as per SANS 1520 Part 1.
- (e) Should any physical alterations be made to a substation, a review on the fire protection system must be done to see if its performance has been compromised and appropriate actions should be made to ensure the integrity of the system.

E04.14 **QA REQUIREMENTS**

The vendor / contractor will be responsible for the following.

TABLE OF CONTENTS			
SECTION	DESCRIPTION	REQUIRED (YES OR NO)	WHEN REQUIRED
DRAWINGS & DESIGN (2 SETS OF EACH)	DESIGN CALCULATIONS		
	GA DRAWINGS	YES	ORDER + 3 WEEKS
	DETAIL DRAWINGS	YES	CONSTRUCTION
	AS BUILT DRAWINGS	YES	COMPLETION
	BROCHURES	YES	CONSTRUCTION
	SKETCHES		
	SCHEMATIC DIAGRAMS	YES	ORDER + 3 WEEKS
	RISK ASSESSMENT BY VENDOR	YES	CONSTRUCTION
	DATA SHEETS	YES	TENDER
	DESIGN CRITERIA	YES	CONSTRUCTION
QUALITY CONTROL DOCUMENTS (2 SETS OF	QUALITY CONTROL PLAN	YES	ORDER + 3 WEEKS
	MANUFACTURING PROGRAM	YES	ORDER + 3 WEEKS

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EACH)			
MATERIAL		YES	MANUFACTURE
CERTIFICATES			
CERTIFICATES OF INSPECTION TESTING AND ACCEPTANCE	PRESSURE TEST CERTIFICATE	YES	DATA BOOK
	ELECTRICAL HAZARD CERTIFICATE		
	ELECTRICAL TEST CERTIFICATES	YES	DATA BOOK
	INSTRUMENT CALIBRATION CERTS.		
	VENDORS CERTIFICATE OF CONFORMANCE	YES	COMMISSIONING
	NON-CONFORMITY / CONCESSION REPORTS	YES	COMMISSIONING
MANUALS	OPERATING / MAINTENANCE MANUAL	YES	COMPLETION
	DATA BOOK	YES	DELIVERY – 1 WEEK
	DRAWINGS	YES	COMPLETION
	WARRANTY/GUARANTEES CERTIFICATES	YES	COMPLETION

E04.15

DRAWINGS AND DATA

- (a) The vendor / contractor will supply shop drawings to the Engineer prior to manufacturing.
- (b) No switchboard manufacturing may start if the drawings are not approved by the Engineer in writing. Should the vendor / contractor start manufacturing without approved shop drawings, any changes required by the Engineer will be for the vendor / contractor's account.
- (c) The following will be included in the shop drawings as a minimum:
 - i. General arrangement drawings
 - ii. Schematic diagrams
 - iii. Equipment lists, including the make, catalogue number and capacity of all equipment such as isolators, circuit breakers, fuses, contractors, etc.
 - iv. All labelling information on a separate sheet.
- (d) The approval of the shop drawings shall not relieve the Contractor of his responsibility to the Client to supply the switchboards according to the requirements of this specification or to the requirements of the Detailed Technical Specification.
- (e) The vendor / contractor will supply three hard copies and one soft copy of the equipment data book including all items as specified in the Vendor QA and document requirement list.
- (f) Data books will be supplied to Johannesburg Water within 7 days from delivery of equipment. Johannesburg Water will review the data books within 14 days from issue and notify the Vendor of its acceptance or rejection of it.
- (g) All drawings and documentation shall be in accordance with Johannesburg Water specifications bound in book format.
- (h) A complete set of "As Built" drawings of all switchboards shall be submitted to the Engineer immediately after completion of the installation. The following information shall be presented:
 - i. Items (i) and (iv) of the previous paragraph.

- ii. Terminal strip numbers, numbers and colours of conductors connected to the terminal strips and numbers and colours of the conductors utilised for the internal wiring.
 - iii. A separate schedule of all equipment.
- (i) Where "As Built" drawings are modified during the execution of the contract, the Contractor shall at his own expense modify or replace such drawings. Accurate drawings of the equipment shall be forwarded to the Engineer.

E04.16 PAINTING AND PROTECTIVE COATING

E04.16.1 Powder Coating Systems

- (a) Paint system 1: Powder Coating, seven Stage zinc, Phosphate pre-treatment, pure epoxy primer, Polyester finishing coat, and thickness 140 µm.

Paint System	Host Material	Preparation	Primer (70µm)	Finishing Coat (70µm)	Thickness µm
No 1	Mild Steel	7 stage phosphate pre-treatment	Epoxy	Epoxy	140

- (b) On completion of the paint job, the powder manufacturer must carry out the following tests on the test panels:
- i. SABS 6J impact test
 - ii. Cross hatch adhesion test
 - iii. Bend test
- (c) The powder manufacturer must issue a Certificate of Compliance for each paint job, which should be included in the contract documentation.
- (d) The preferred corrosion protection systems are applied onto cold rolled mild steel plate with a thickness of 2.0mm.

E04.16.2 Epoxy Powder Coat Products

Item	Product Type	Powder - Lak
1	Epoxy Primer	23-007
2	Pure Epoxy / Polyester Finishing Coat.	Series 3000

E04.16.3 General

- (a) All chassis plates shall be painted white.
- (b) All mild steel gland plates shall be galvanised for improved cable earthing.
- (c) All panel doors on equipment supplied from a normal supply must be painted Electric Orange (B26).
- (d) All panel doors on equipment supplied from an emergency supply must be painted Signal Red (A11).
- (e) All panel doors on equipment supplied from an UPS supply must be painted Dark Violet (F06).
- (f) Specific external colours will be provided by Johannesburg Water.
- (g) Before the installation is handed over, the Contractor shall ensure that all paint surfaces are clean and undamaged.

E04.17 PERFORMANCE AND GUARANTEE

- (a) The performance of the items supplied in terms of this specification, as defined by the order, shall be warranted by the Vendor and, if specified, be tested in accordance therewith.
- (b) The vendor shall not be specifically required to conduct a performance test on site.
- (c) A minimum warranty period of 12 months is required.

E04.18 INSPECTION AND TESTING

E04.18.1 Factory Acceptance Test

- (a) The Johannesburg Water Representative shall have access, at all reasonable times, to those parts of the manufacturing facilities engaged in the manufacturing of items in terms of this specification. He is authorised to witness any stage of manufacture, tests and inspect documentation.
- (b) The Johannesburg Water Representative is authorised to reject any items not manufactured to the requirements of the specification.
- (c) All equipment shall be inspected at the vendor's works prior to delivery, to ensure compliance with the specification.
- (d) No unit shall be considered complete until acceptance by Johannesburg Water.
- (e) The minimum testing / pre delivery checklist shall be as follows:
 - i. The Johannesburg Water representative must carry out a clause-by-clause check of each switchboard, prior to delivery.
 - ii. This switchboard checklist is intended to assist this process but does not relieve him/her of the responsibility described above.

DETAILED INSPECTION ROUTINE

Order No. : _____

Supplier/Vendor : _____

Project : _____

Motor Control Centre Designation : _____

Inspected by : _____

Date : _____

	Comments
Overall Appearance	
<input type="checkbox"/>	
<input type="checkbox"/> Paint work : Compliance with Annexure A5	
<input type="checkbox"/> Paint thickness	
<input type="checkbox"/> Door fittings good	
<input type="checkbox"/> Dust sealing effective (neoprene seals)	
<input type="checkbox"/> Board fully assembled	
<input type="checkbox"/> Overall height less than specified height	
<input type="checkbox"/> Channel iron base frame (less than 3000m)	
<input type="checkbox"/> Lifting lugs provided	
<input type="checkbox"/> Equipment supplied in accordance with specification (contractors, overloads, circuit breakers, relays, etc.)	

	Comments
Busbars	
<input type="checkbox"/> Correct cross-section	
<input type="checkbox"/> Correct phasing with incomer/feeders	
<input type="checkbox"/> Rigidly supported/braced	
<input type="checkbox"/> Properly insulated	
<input type="checkbox"/> Joints tightened	
<input type="checkbox"/> Transport section joints supplied (Fishplates, nuts and bolts, control wiring and terminals, etc.)	
<input type="checkbox"/> Droppers from main bars to circuit breakers adequately rated, braced, insulated	
<input type="checkbox"/> Nothing unnecessary mounted on bus bars	
<input type="checkbox"/> Main earth bar, min 70mm ²	
<input type="checkbox"/> Control busbars generally as above, separate from power busbars	
<input type="checkbox"/> Air clearances adequate throughout	
Single Line Diagram Check	
<input type="checkbox"/> As per approved single line diagram	
Outgoing Circuit	
<input type="checkbox"/> Correct size/rating for MCCB's	
<input type="checkbox"/> Correct size/rating for ACB's	
<input type="checkbox"/> Correct earth leakage relays	
<input type="checkbox"/> Correct current transformer and associated ammeters	
<input type="checkbox"/> Correct overload relays	
<input type="checkbox"/> Correct setting on overload relays	
<input type="checkbox"/> Reasonable provision for cable termination power and control mounting of equipment	
<input type="checkbox"/> Correct conductor sizing, power and control, and correct colouring	
<input type="checkbox"/> Correct indicator lights and colours	
<input type="checkbox"/> Air clearances correct throughout	
Incoming Circuits	
<input type="checkbox"/> Correct size/rating of ACB's	
<input type="checkbox"/> Correct metering and proper mounting	
<input type="checkbox"/> Connection of power factor meter	
<input type="checkbox"/> Fuses on volt meter, where applicable	
<input type="checkbox"/> Reasonable provision for termination of incoming cable/gland plate	
<input type="checkbox"/> Air clearances correct throughout	
Incomer status signal to PLC	
Interlocks	
Pressure and Injection Tests	
<input type="checkbox"/> Primary injection test for correct operation of all protection and overload relays	
Operational Test	
<input type="checkbox"/> Mechanical operation of all circuit breakers, preferably with doors closed	
<input type="checkbox"/> Shunt trip of all circuit breakers	
<input type="checkbox"/> Operation of overload relay	
<input type="checkbox"/> Correct operation of all interlocks	
<input type="checkbox"/> Correct operation of indicator lights	

	Comments
<input type="checkbox"/> Correct operation of earth fault/overload alarm system, including general alarm panel	
Correct signals to PLC terminals	
Correct interlocks	
Door interlocks	
General Checks	
<input type="checkbox"/> Marking of control wires and power conductors	
<input type="checkbox"/> Main Motor Control Centre label	
<input type="checkbox"/> Cubicle labels fitted – designation and cubicle number	
<input type="checkbox"/> Component labels fitted	
<input type="checkbox"/> Warning labels on all removable covers giving access to live 400V conductors	
<input type="checkbox"/> Labels for indicator lights, pushbuttons, etc.	
<input type="checkbox"/> Terminal strip labels	
<input type="checkbox"/> Incoming side of circuit breakers label	
<input type="checkbox"/> Incoming circuit label – “FROM _____”	
<input type="checkbox"/> No ‘Philips’ (star) screws	
<input type="checkbox"/> No self-tapping screws	
<input type="checkbox"/> Grommets fitted on all open holes	
<input type="checkbox"/> Correct paint specification	
<input type="checkbox"/> All documentation submitted	
<input type="checkbox"/> Arc venting arrangements satisfactory	
<input type="checkbox"/> Door latches fitted	

- (f) Specific testing and inspection requirements relating to switchgear boards are as follows:
- i. Prior to shipment, the switchgear boards shall be completely assembled, wired, adjusted and tested by the supplier in the presence of the engineer and the client representative.
 - ii. Testing shall include primary injection tests of all current transformers, pressure tests to prove quality of insulation, functional tests of all mechanical and electrical components and electrical circuitry and any other tests required to ensure compliance with this specification.
 - iii. The supplier shall give one week's notice of readiness for final tests to the Johannesburg Water representative. The vendor shall ensure that the equipment is ready for final testing before requesting the presence of the Johannesburg Water representative at such a test. Repeat inspections necessitated by the lack of readiness of the equipment may be charged to the vendor at the discretion of the Johannesburg Water representative.

E04.18.2 Site Acceptance Test and Commissioning

- (a) A Site Acceptance Test (SAT) must be conducted at the place of installation prior to switching the DB on. The test shall include (as a minimum) the following:
- i. A visual inspection to ensure all the design specifications are adhered to;
 - ii. Insulation resistance test;
 - iii. Function testing of all components.
 - iv. All switchboards must be thermal imaged a minimum of 1 week after being put on service. The image must be taken in normal operating conditions. The image must be analysed for hot spots and must be part of the Operations and Maintenance

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Manuals presented at the end of the project.

E04.19

MEASUREMENT AND PAYMENT

Item	Unit
Supply and deliver Switchboards or Motor Control Centres.....	No

The unit of measurement shall be the number of MCC's or boards supplied and delivered.

The tendered rate shall include full compensation for the manufacture, supply, testing and delivery of the boards as specified in the detailed specification.

Item	Unit
Install Switchboards or Motor Control Centres	No

The unit of measurement shall be the number of MCC's or boards installed.

The tendered rates shall include full compensation for the installation of the specified boards, including all required installation material to install the MCC or board in the required position including a heavy-duty strut, mounted 400mm below the gland plate. All incoming and outgoing cables shall be attached to this strut by means of K-clamps or approved equivalent clamps.

Item	Unit
Commission Switchboards or Motor Control Centres	No

The unit of measurement shall be the number of MCC's or boards.

The tendered rates shall include full compensation for the site testing and commissioning of the specified boards including the keeping of all commissioning records in triplicate, including all material, test equipment and labour required for the testing and commissioning.

Item	Unit
Supply and install extra circuits on Switchboards and Motor Control Centres	No

The unit of measurement shall be the number of circuits supplied and installed.

The tendered rate shall include full compensation for the manufacture, supply, testing and installing of extra circuits in switchboards or motor control centres (spare space being available on the board).

Item	Unit
Supply and deliver level control equipment	No

The unit of measure shall be the number of level control systems supplied and delivered.

The tendered rate shall include full compensation for the supply, manufacturing, testing and delivery of all the material required for the level control system, including all float level switches, will the required length of cable attached to them, mounting brackets, terminal box and mounting equipment together will all material to facilitate a complete level control system.

Separate items will be measured for systems with different numbers of level switches.

Item	Unit
Install level control equipment.....	No

The unit of measure shall be the number of level control systems installed.

The tendered rate shall include full compensation for installing, testing and commissioning of the level control system including the required brackets, junction boxes, cables etc. for a complete working system.

Item	Unit
Modify existing motor starter panels	No

The unit of measure shall be the number of motor starters to be modified.

The tendered rate shall include full compensation for the supply and delivery of all material and labour required to modify the motor starter panel as detailed in the detail specification.

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Item	Unit
Supply and install PLC/Scada alarm and status signals	No

The unit of measure shall be the number of MCC's for which a siren and alarm light has been installed.

The tendered rate shall include for the full compensation for the supply, delivery, installation and commissioning of the specified siren and alarm light including all required installation material including cables required to render a fully operational system.

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