EWS STANDARD SPECIFICATIONS

GS.1 STANDARD SPECIFICATION FOR DB's AND MOTOR CONTROL CENTRES

(FOR HEAVY INDUSTRIAL AND COMMERCIAL USE)

All major motor control centres and equipment shall be designed in accordance with SANS 1473/60439. The equipment shall conform to SANS 60947 Parts 1-7, unless otherwise stated and shall be suitable for operation on supply voltages of 230/400 Volts and 500/550 Volts, 50Hz, AC. Reference must be made to the detailed technical specification, the relevant line diagram if provided, as well as the following specific requirements.

In addition the design must conform to the following standards:

- **Act No. 85 of 1993 Occupational Health and Safety Act.**
- **SANS 10142 Code of Practice for the Wiring of Premises**
- **Relevant SANS specifications and Codes of Practice**
- **Relevant BSI Specifications and Codes of Practice in the absence of published SANS documents.**
  Relevant IEC Specifications and Codes of Practice in the absence of published SANS and BSI documents.

GS.1.1 CONSTRUCTION OF MOTOR CONTROL CENTRE ASSEMBLIES

All motor control centres shall generally be of the free standing, floor mounted, individual starter with local isolator for each motor type, with front and back access, suitable for bottom cable entries from cable trenches below the assembly. The schematic drawings or project specification show the specific requirements applicable to each assembly.

The assembly will be constructed of powder coated 3CR-12 having a minimum thickness of 2mm except for gland plates which shall be a minimum of 3mm. If thinner material is offered, offered, the construction technique must be approved by the Employer's representative prior to fabrication.

Where specified the assembly enclosure may be required to be manufactured from stainless steel.

The degree of protection shall not be less than IP 43, in accordance with SANS 1222 and capable of withstanding the temperature, humidity and conditions normally associated with heavy industrial applications. The assembly shall be fully vermin proofed.

A hot dipped galvanized steel base frame shall be provided and removable lifting eyes with blanking off plugs shall be provided for heavy assemblies. All panels shall be suitably braced to ensure rigidity.

The MCC's are to be fully assembled in the manufacturer's factory for final acceptance tests. Where broken down for transportation to site, the MCC's will be provided with all items required for re-assembly. Provision must be made for future extension at either side of the MCC. All holes provided for such extension to be suitably plugged or covered.

The overall outside dimensions of the assembly shall be suitable for easy handling of the switchgear. The height of the assembly shall generally not exceed 2100mm above floor level.

All doors shall be fitted with stainless steel or heavy duty rustproof hinges of Barker & Nelson or Zeus manufacture and shall be secured in the closed position by means of locking devices of approved quality. Doors in excess of 450mm height shall be secured at both the top and bottom. Lockable catches are required on all doors. All doors are to be fitted with earth straps.

Covers, other than the hinges type, shall be provided with chromium plated handles to facilitate removal. Removable covers shall be secured in position by means of patent screw locking devices approved by the Employer's Representative. All the equipment shall be mounted behind the doors and neat machine punched openings shall be provided for the purpose of operating handles etc. Employer's Representative's drawings or specifications will detail the instruments required which will be flush mounted. The positions of instruments shall be such that the glass cannot be broken by other equipment when the doors are in the fully open position.

Cut outs which are provided for future equipment and instruments shall be neatly blanked off by means of removable dummy frames. Back plates shall be provided in all spare cubicles for the specified future starters.

The manufacturer's detailed working drawings of the assembly must be approved by the Employer's Representative before any fabrication commences. Any other construction or type of assembly proposed as an alternative to that specified, must have the approval of the Employer's Representative in writing. The drawings will detail all dimensions of busbars, connections, electrical components, make, type and rating. Position and layout of busbars, earth bars and gland plates must be shown in front and side elevation drawings.

GS.1.2 **PAINT SPECIFICATION**

In general, the following standard colours shall be used, but the final colours are to be confirmed with the Employee's Representative.

Non-essential section	Electric orange (Colour B26 – SANS 1091)
Essential sections	Signal red (Colour A11 – SANS 1091)
Uninterrupted power (UPS)	Electric orange (Colour B26 – SANS 1091)
Instrumentation and control	Electric orange (Colour B26 – SANS 1091)

GS.1.3 **BUSBARS**

All busbars shall be manufactured from solid high conductivity copper and shall comply with the requirements laid down in SANS 1195. The completed busbar system shall be a standard modular system and shall have been tested to SANS approval and a certificate shall be made available confirming the full busbar technical description, current rating and fault rating together with full details of the test results.

The busbar assembly shall be rated in accordance with the specified ultimate projected faulted level, which will be not less that the short–circuit stresses limited by the protective device(s) on the supply side of the busbars, as well as the specified continuous full load current, with a current density not exceeding 1.60 Amps per mm^2.

The busbars shall be continuously rated for the specified current with a maximum temperature of 40°C relative to a peak ambient temperature of 40°C giving a maximum peak busbar temperature of 80°C.

Busbars shall be mounted in the top section of the assembly and shall be rigidly supported by means of approved insulated busbar clamps to prevent damage resulting from the specified short circuit conditions.

The busbars shall run along the entire length of the assembly up to 76mm from either end. The phase busbars shall be identified in the phase colours red, white and blue.

The busbars shall be arranged horizontally with the longer side of the cross-section in the vertical plane and one behind the other in the horizontal plane. The minimum clearance between live conductors and live conductors and earth shall be 40mm.

GS.1.4 **BUSBAR DROPPERS**

All busbar droppers must be suitably supported and braced to suit the specified and/or project short circuit conditions. They should be fully insulated and screened against accidental contact.

The droppers to the supply side of a single functional unit, as well as the components included in this unit, may be rated on the basis of the reduced short-circuit stresses occurring on the load side of the short-circuit protective device in this unit provided that these conductors are arranged such that under normal operating conditions an internal short-circuit between phases and/or between phases and earth is only a remote possibility, for example by being provided with adequate insulation or shrouding.

Particular attention shall be paid to the provision of adequate facilities for making off the main power supply cables. Attention must be paid to the vermin proofing of single core cabling.

Bunched cable connections will not be accepted between busbars and outgoing power circuit breakers, fuses or isolators.

GS.1.5 **EARTH BUSBAR**

A solid copper earth bar shall be provided inside each assembly at the back and along the entire length, at a height of approximately 500mm above floor level, or 200mm above the gland plates. A bar is to be provided at the top of the assembly where top entries exist and this shall be solidity connected to the bottom earth bar.

The earth bar will be supported on robust spacers and will have a minimum clearance of 40mm to the sheet steel panel.

The earth bar shall have a cross-section of not less than 40mm x 6mm and shall be drilled with the requisite number of holes for the individual connection of all cable ECC and other earth conductors.

High tensile phosphor bronze or cadmium plated nuts, bolts and lock washers shall be provided through the earth bar at each earth position and at least 5 additional holes will be provided for future connections, each being fitted with nuts and bolts as above.

The earthing positions shall be evenly spaced along the length of the earth bar and the bar must be clearly identified as the earth.

GS.1.6 **BUSBAR CONNECTIONS**

All connections and extensions to busbars shall be effected by means of high tensile phosphor bronze nuts, bolts and washers or cadmium plated, high tensile steel bolts and nuts which shall also be provided for future extensions. The minimum diameter of any holes will be 10mm.

In exceptional cases a relaxation of SANS 1973 may be permitted to allow the drilling of holes, in which case the cross-sectional area as measured is to be reduced by the area of the holes.

GS.1.7 **EQUIPMENT**

Unless otherwise stated on the drawings or as specified, the latest version of the following minimum specifications shall be assumed for equipment to be installed in the switchboards.

Busbars	SANS 1195
Circuit breakers	SANS 60947 Part 2 and SANS 156
Switches, disconnectors and fuse Combination units	SANS 60947 Part 3
Contactors and motor starters	SANS 60947 Part 4
Control circuit devices and switching Elements	SANS 60947 Part 5
Multi-function switching devices	SANS 60947 Part 6
Ancillary Equipment	SANS 60947 Part 7
HRC fuses and fuse switches	SANS 60269

SANS 60947 relates specifically to equipment for use at voltages up to 500 Volts

Where a voltage in excess of 500 Volts is specified, the manufacturer must confirm that the equipment is suitable and has been tested to that higher voltage.

The equipment to be mounted in the panels will be detailed in the drawings or as specified and schedules provided.

All contactors and/or starters shall be protected with suitable back-up HRC fuses or current limiting circuit breakers to protect the equipment against abnormally high currents or short circuits developing in the system.

The manufacturer will be required to ensure the correct co-ordination between fuses, contactors and overload relays to comply fully with SANS 60947 Part 4 in order to achieve "Type 2" co-ordination. Current limiting circuit breakers will only be permitted if the manufacturer submits full details of tests results confirming to Type 2 co-ordination.

Unless otherwise stated, contactors and/or starters shall be rated for 10 million operations for making and breaking no-load current to category AC3 as laid down in SANS 60947. Note that SANS 60947 requires equipment and wiring to be suitable for 7.2 x FLC for DOL starters.

Access to the various starters shall be possible without isolation of the entire MCC, but the doors corresponding to each compartment shall be inter-locked with a local isolator in order that any compartment must be isolated before access to the equipment can be obtained. A mechanical device shall be incorporated in each isolation in the off position to provide a locking out facility during maintenance periods.

Timers and relays controlling a starter shall be mounted in the compartment with the starter. All timers and relays must be clearly labelled with the identity given on the schematic diagrams.

GS.1.8 DERATING OF EQUIPMENT

Full cognizance must be taken of manufacturers derating tables of equipment located in enclosures and the rating of that equipment must be increased accordingly. In all such cases labels must be provided on the front of the associated cubicle stating the maximum permitted circuit loading.

Where high ambient temperature and/or continual high loadings are anticipated, the assembly must incorporate adequate ventilation systems to eliminate the possible build-up of excessive temperatures or humidity. Where specified, renewable filter elements must be incorporated.

GS.1.9 CABLE TERMINATIONS

Due to the continuing miniaturization of equipment, difficulties can be experienced in terminating power cables onto equipment terminals, particularly where more than one cable has to be terminated. The manufacturer shall ensure that suitably designed and rigidly braced copper stubs are extended from such terminals to facilitate the termination of all cables.

GS.1.10 INSTRUMENTATION

All instruments shall be of a matching flush pattern, preferably with a 96mm x 96mm square dial.

All main incoming panels shall be provided with three combined maximum demand/instantaneous ammeters, a voltmeter and selector switch as well as any additional instrumentation detailed on the single line diagrams or as specified.

GS.1.11 AMMETERS

Combined maximum demand type instruments will comprise a moving iron ammeter showing the instantaneous current value, combined with an ambient corrected, manually reset, thermal maximum indicating ammeter which will indicate the mean current reached during any 15 minute period.

The starter cubicles for all motors rated at 11kW and above and all motor driven pumps irrespective of size shall be provided with an ammeter, which shall incorporate an adjustable red pointer and an extended starting characteristic. Allowance must be made for the full load current of all motors to be checked and for all red pointers to be set accordingly.

GS.1.12 **CURRENT TRANSFORMERS**

Where applicable, the current transformers shall generally be of the ring type complying with the requirements of SANS 60044-1, as amended. The current transformers shall have a Class 3 or 5 accuracy.

GS.1.13 **VOLTMETER**

Voltmeters shall be of the moving iron, suppressed zero type, having a full scale deflection of not less than 480 Volts, unless otherwise specified.

GS.1.14 **VOLTMETER SELECTOR SWITCH**

All voltmeter selector switches shall be wired to connect the voltmeter between all phases and each phase and neutral and shall disconnect it in the OFF position. The switch shall have a position located switching mechanism.

GS.1.15 **INSTRUMENTATION FUSES**

All instrument fuses shall be mounted in the panel onto or next to the busbars. 6mm² wiring shall be used between the busbars and the fuses and shall be kept as short as possible.

HRC cartridge fuse links to SANS 60269 shall be used and shall incorporate visual indication devices to facilitate the location of blown fuses on visual inspection. They shall be designed to clip into the fuse carrier contacts without the use of fixing screws.

Wiring from fuses bases to instruments may be bunched but must be suitably supported in Bowthorpe Hellerman trunking or lacing.

GS.1.16 **PROTECTIVE DEVICES AND PROTECTION SETTING**

The switchgear shall be provided with the specified protection and auxiliary relays, which must be of a modular pattern, readily accessible, replaceable and extensible.

The thermal overload releases and instantaneous magnetic short circuit trips are to be adjustable over the trip ranges as specified by the Employer's Representative.

The contractor must allow to grade, set and test the protection devices for the main switch, bus section switches and each motor circuit.

GS.1.17 **PUSH BUTTONS AND INDICATING LIGHTS**

Unless otherwise indicated, the following is the minimum requirement for illuminated push button and indicating lights:

START and STOP push buttons

RUN, STOP, THERMISTORS and HEATER lights

Indicator lamps may only be of the neon or LED types. Where LED's are used as indicators on main supply voltages, a suitable current limiting capacitor and reverse voltage protection diode must be used. For low AC or DC voltage (±24V) a current limiting resistor will suffice.

GS.1.18 CONTROL VOLTAGE SUPPLY /BACK UP SUPPLY

The control voltage shall be provided by a single phase, double wound transformer supplied from the Red and White phases of the main busbars, with the secondary voltage as specified on the schematic diagrams or as specified.

The primary and secondary connections are to be provided by suitably rated and labelled HRC fuses.

Unless otherwise specified, the transformer shall be rated at 0.8 x (total hold-on VA of all contractors plus VA of all lights and relays plus pull-in VA of largest device) with a further additional allowance of 50% for future extensions.

Should the main busbar system incorporate a bus-coupler, 2 control transformers shall be provided. Supplies to the 2 transformers shall be controlled by contactors interlocked to ensure that only one transformer supplies the control circuit at any one time.

Where suitable, a control voltage busbar shall be provided along the length of the MCC.A power supply unit with backup up battery for the PLC is to be installed and wired in a separate cubicle. The 12V DC circuit must be supplied by a 25W DC/DC converter for equipment using 12 Volts (eg. room security sensors). Two (2) backup batteries are to be low maintenance sealed lead acid type of 12 V DC 70AH.

GS.1.19 CABLING, WIRING AND TERMINALS

GS.1.19.1 STARTER WIRING

Particular attention shall be paid to be the method of wiring from busbars to the individual compartments, in order to avoid any cable crossing through a compartment with which it is unrelated.

The wiring between all starter components, isolators, fuses, contactors, overload relays and terminals is to be rated to suit the maximum capacity of the starter and is to be not less than 6mm².

Three phase panels shall be wired in red, yellow and blue PVC insulated conductors for the phases, black for neutral and green earthed circuits.

Single phase panels shall be wired in red and black PVC insulated conductors, for phase and neutral respectively and green for earthed circuits.

Neutral connections shall be black and this colour must not be used for any other wiring.

Multi-stranded or laminated conductors shall be used between all items of equipment in preference to solid conductors. The insulation of these conductors shall not be stripped beyond the leading edge of the terminal in which it has to be accommodated.

Stripping shall be carried out without damage to the conductors, preferably by means of a cable stripper.

Approved crimping lugs and ferrules or approved clamps shall be used for connection into equipment not provided with compression type terminals.

All panel wiring shall be completed and installed at the MCC manufacturing works. The wiring shall be loomed or encased in PVC cable trunking of Hellerman manufacture or equal approved and shall be carried out neatly along vertical and horizontal lines.

GS.1.19.2 CONTROL AND INSTRUMENTATION

Suitably protected control supervisory and auxiliary circuits must be wired with 1 mm² conductors. The wire colour codes must be according to SANS 10142-1:2012. Edition 1.8

220 Vac	-Red
Neutral	-Black
+24 Vdc	-Grey (Marked +24Vdc)
-24 Vdc	-Blue
12 Vdc	-Yellow (Marked +12Vdc)
-12 Vdc	-Blue
Telemetry	-Purple

Each end of the conductor shall be terminated in a pre-insulated, spade or pin type lug, applied by means of the recommended colour coded crimping tool. All control wiring shall be clearly marked by interlocking plastic ferrules, the numbers corresponding to wire numbers on the schematic diagrams.

If control and/or supervisory wiring is required for equipment which is installed on the doors of the panel the wiring shall be bunched together and suitably strapped with spiral binding in the form of a vertical "U" loop between the door and the panel, to ensure that there is no tension on the wiring when the door is rotated along is vertical axis. Approved wiring supports shall be fixed onto the hinged panels, to relieve the weight of the cables off the equipment terminals. Each door shall be suitably earthed.

GS.1.19.3 **POWER CABLE TERMINATIONS**

Sufficient space must be allowed for the connection of all known and future incoming and outgoing cables.

Outgoing cables shall be glanded off on galvanized gland plates at the bottom or top of the vertical cables ways. Where top access is required, it will be specified in the tender document.

Approved shrouded and shielded terminals shall be provided for the outgoing connections to each motor for conductors up to and including 35mm², rated at least 50% in excess of the conductor rating. The terminals shall be fixed in the vertical cables way of the assembly and shall have ample space for making off the outgoing cable terminations.

Conductors of 50mm² and above shall be terminated directly onto the starter equipment, but the cables must be adequately supported to ensure that no strain is imposed on the equipment.

GS.1.20 **GLAND PLATES**

A strong and robust 3mm hot dipped galvanized cable gland shall be provided along the entire length of the assembly at a minimum height of 300mm above floor level. The gland plate shall be constructed in sections and bolted in position to take the load of the cables being glanded to it.

When cables enter/exit from the top of the board, the top cover plate will act as the cable gland plate and shall also be 3mm thick. It shall be bolted to the frame do that it can be removed if necessary. The terminals associated with these cables will be mounted not less than 200mm below the top cover plate.

All gland plates shall be machine punched in the factory to suit each and every cable gland required. Under no circumstances will any drilling or filing be allowed on site.

GS.1.21 **OUTGOING POWER CIRCUITS**

All cables shall be terminated with approved glands to suit the application. Particular attention shall be paid to the termination of ECC cabling to ensure the continuity of all earth conductors.

Every termination of a power cable shall be provided with an approved numbered Bowthorpe Hellerman tag identifying its size and destination, fixed below the cable gland plate in a position which is easily observed from the front to the boards. This procedure must also be incorporated at the motor termination box.

GS1.22 **MARSHALLING COMPARTMENTS**

When specified, marshalling compartments shall be provided for control circuit wiring.

The marshalling compartment shall be adequately sized to accommodate all the required terminals PLUS provision for a further 50% spare terminals.

Where a motor control centre is to be broken down for transportation to site, each section shall be provided with a marshalling compartment to the above requirement so that the associated wiring is not disturbed.

Where such control circuits are unavoidable and control wiring has to cross a break, it shall be suitably identified and disconnected at one end during transportation.

Terminals for each starter should be grouped together and clearly identified by a permanently affixed label. Terminals shall be mounted on rails and space shall be provided for spare terminals after each group of terminals.

A suitable gland shall be provided for terminating the control cables and adequately sized cable way shall be provided for running the cable ends to the terminals in the marshalling compartment.

A 220 Volt switched socket outlet shall be provided in each marshalling cubicle. Where specified, a switched light shall also be provided.

GS.1.23 **SURGE DIVERTERS AND 4-20 MA LOOPS**

Where specified the MCC is to be equipped with surge diverters of approved manufacture and bearing the SANS mark.

The arrestors or diverters shall be mounted inside the panel on the incoming unit. The supply side connections shall be made in the factory to the three phase busbars, whilst the earth side connections shall be made to the earth bar of the board.

All 4-20 mA loops are to be electrically isolated from the PLC analogue input by means of an isolator unit or splitter unit.

All loops entering the panel from the field must be protected by means of surge protection units. With circuit breaker protection, equal or approved. All surge protection units are to be bonded to earth by means of 4mm² multi strand earth cable.

GS.1.24 **SPARE FUSE CARTRIDGES**

Where HRC or other cartridge types fuses are specified or used to protect instruments or circuits, the MCC shall be suitably equipped with a compartment for housing one third of all fuse cartridges specified, having a minimum of 1 set (i.e. 3 phase) of fuses of each size specified and all such spare fuses shall be provided inside this compartment on handing over. The compartment shall be clearly labelled: “Spare fuse cartridge”: replace used-up fuses.

GS.1.25 **LABELS**

The requirements of SANS 10142-1 must be complied with.

All boards or panels shall be fully labelled using sandwich type labels, fixed to the board or panel by means of either screws or rivets, or by gluing into metal label holders which are bolted to the board.

Labels should be black lettering on a white background, not less than 6mm in height and mounted centrally below each respective starter unit, in an approved position. A centrally mounted label shall be provided to indicate the manufacturer’s details, the design busbar rating and asymmetrical fault level.

A label indicating where the board is “Fed From” shall also be fixed to each MCC.

All relays and wiring terminal blocks inside the MCC shall be labelled to clearly identify the control gear and wiring to equipment.

The cable markings shall indicate the number of cores – core cross sectional area – original of the cable – cable number, of the cable. E.g.

4-35-M-01
2-2.5-M-02

Pump 1 cables

3-10-P1-01
7-1-P1-02

Pump 2 cables

3-10-P2-01
7-1-P2-02

Pump 3 cables

3-10-P3-01
7-1-P3-02

GS.1.26 **WORK TESTS**

The MCC shall be fully assembled and wired before being dispatched from the works. The Contractor and the switchboard manufacturer will carry out a full functional test to prove the correct operation of the entire MCC, including interlocking, remote control and the simulation of all protection devices. All other circuits external to the switchboard will be simulated and will be tested accordingly.

All MCC’s with a fault level of 10kA or more shall be type tested by an accredited person and a signed certificate issued with the MCC, The costs of all these tests shall be borne by the contractor, The tests shall be witnessed by the Employer’s Representative.

Unless otherwise specified, the correct function of the PLC hardware will not be the responsibility of the MCC manufacturer, but the contractor will be expected to have an artisan standing by during tests in order to observe the MCC operations and carry out any remedial work required.

The tests shall be witnessed by the Employer’s Representative and shall be recorded in triplicate on approved test forms.

GS 1.27 **SOFT STARTER**

Conformity of standards

EC
The soft starter shall be constructed and tested in accordance with the international IEC standards EN 60947-1 and EN 60947-4-2 and respect the following EC directives:

- “Low voltage Equipment” No. 2006/95/EC
- “Electromagnetic compatibility Directive” (EMC) No.2004/108/EC

UL
The soft starter shall be constructed and tested in accordance with UL 508.

Product features
The soft starter shall comply with the following technical requirements:

General specification

- Three phase control with operation voltage: 208 - 600VAC or 208 - 690VAC, 50/60 Hz
- Wide rated control supply voltage: 100 - 250VAC 50/60 Hz
- Built-in bypass to reduce energy consumption at full speed and increase the life time of soft starter.
- Possibility for both in-line and inside-delta connection of the motor
- The soft starter shall have built-in Modbus RTU for communication. Support for other protocols shall be an option.
- The soft starter shall be equipped with one analog output
- The soft starter shall have a minimum of 3 signal Relays Output for Run, Bypass (Top of Ramp) and Event signal.

User interface

- The soft starter shall support multiple languages in both the manual and HMI, including: English, Swedish, German, French, Italian, Spanish, Portuguese, Dutch, Polish, Russian, Finish, Turkish, Czech, Chinese and Arabic.
- The soft starter shall have a detachable keypad with graphical LCD display. The keypad shall have start and stop buttons, information button for access to a built-in manual and an USB-port for connection to a PC.

Environmental conditions

- The soft starter shall have coated PCBAs to withstand harsh environments
- The soft starter shall support operational temperature of -25 to +60℃ with de-rating of maximum 0.8% per ℃ above 40℃
- The soft starter shall be able to operate on up to 4000 meters above sea level with de-rating of maximum 0.67% per meter above 1000 meters

Motor starting, stopping and operation

- The soft starter shall have pre-start functions:
    - Stand still brake, to keep the load still before start
    - Motor heating, to keep the motor well-tempered before start
- The soft starter shall have the following start ramps available:
    - Voltage start ramp
    - Torque start ramp
    - Full voltage start
- The soft starter shall have possibility for slow speed forward and backward operation for positioning of a motor load.
- The soft starter shall have Torque Control and pump cleaning feature, to eliminate water hammering and prolong lifetime of the pump system.
- The soft starter shall include a kick start feature to be able to start heavy loads.
- The soft starter shall have the following three types of current Limit:
    - Current Limit
    - Dual Current Limit
    - Current Ramp
- The soft starter shall have a limp mode feature to allow the soft starter to operate even with shorted thyristors in one phase.
- The soft starter shall have possibility for sequence start of up to 3 different motors.

Built-in motor protections

The soft starter shall integrate motor and load protections, which shall under no circumstances be disabled when the integrated bypass is used. The soft starter shall also be able to present a warning before tripping for each protection.
The soft starter shall have the following motor protections available

- Electronic Overload Protection, class 10A, 10, 20, 30
- Locked Rotor Protection
- Motor Underload Protection
- Current Imbalance Protection
- Voltage Imbalance Protection
- Overvoltage and Under Voltage Protection
- Phase Reversal Protection
- Earth-fault Protection

It shall also have input for PTC and PT100.

Built-in diagnostics
The soft starter shall have the following diagnostics features:
- THD(U)-Total Harmonic Distortion
- Counted number of start sequences
- Motor runtime measurement
- Thyristor runtime measurement
- Auto phase sequence detection
- Electricity metering
- Voltage sags detection
- Time to trip estimation
- Time to cool estimation

Fault detection
The soft starter shall provide following fault detection, to protect both the starting equipment, the load and the soft starter itself
- Phase loss
- High current
- Low control supply voltage
- Fault connection
- Bad network quality
- Thyristor overload

GS1.28 **VARIABLE SPEED DRIVES**

1. General

This part of the specification describes the general requirements for the Variable Speed Drives, the VSDs. The nominal values, the standard documents and the drive's minimum performance are defined in this part. The VSD does not include motor in this specification. The specification uses the term Motor unit which means a combination of the VSD and the motor.

If the project-specific part of the specification (Appendix A) is in contradiction with the other parts of the document, the project-specific document shall apply.

2. Requirements for the Manufacturer

2.1 Certifications

The Frequency Converter Manufacturer shall have a valid ISO 9001 certification and an applicable quality assurance system.

The Manufacturer shall have the Environment Certification ISO 14001.

2.2 Experience

The Manufacturer shall have adequate experience in frequency converter manufacturing and have adequate business volume in order to provide credibility in his commitments and a capability of long term support. The Manufacturer shall prove his experience by quoting references of units in the specified power and voltage range.

2.3 Local support

The Supplier shall have a permanent representative office with a trained and skilled support staff, in the country where the goods are delivered, in order to prove his commitment for local support and to provide a channel for communication. The local representatives shall be easily accessible and shall be able to arrive at the site within 24 to 48 hours' notice.

The engineers employed by the Supplier's regional office shall be certified by the Manufacturer and provide start-up service including physical inspection of the drive, connected wiring and final adjustments, to ensure that the VSD meets the required performance.

The Supplier shall be able to give basic drives training to the Customer's engineers, preferably on the site but anyway, in the country where the customer's site is. The training shall, as a minimum, include system concepts and basic troubleshooting. The Supplier shall also be capable of solving most VSD problems quickly. He shall also have a 24-hour support from the Drives Factory, to avoid any delays during service or repair work on the site.

The Manufacturer shall be able to offer commissioning of the drive to be done by the local office.

The most common spare parts like fuses, IGBTs as well as main control- and IO-boards shall be available in 48 hours from the notification through a regional service center of the Supplier. The more rarely used spare parts should be available in maximum 5 days on site!

3. Basic requirements for the VSDs

3.1 General requirements

The VSD shall be of the most modern design, yet user friendly and be simple to install, commission and maintain. The VSD shall be able to start and control the speed of a standard squirrel cage induction AC motor. The VSDs shall be CE marked. The VSDs have to be built to comply with the IEC standards. In the Australian market the VSDs shall have a C-tick.

The materials used in the VSD shall be recyclable, non-toxic and flame retardant.

The VSD shall be a digitally controlled drive, using, at least, the Pulse Width Modulation (PWM) with flux vector control, a Direct Torque Control (DTC), or equivalent. It shall have IGBT's in the inverter section of the throughout the power range, and it shall have the following minimum specifications.

Operating conditions:

Rated Input Voltage	:	380V - 415V, three-phase, $\pm$ 10% or
	:	380V – 500V, three-phase, $\pm$ 10% or
	:	525V – 690V, three-phase, - 10%, + 5%
Rated Input Frequency	:	48 - 63Hz
Fundamental Power Factor	:	0.97 or better at nominal load
Efficiency	:	$\geq$ 98 % at nominal load
Output Voltage	:	0 - U_N, three-phase
Output Frequency Range	:	0 to 300 Hz, adjustable
Output Frequency Resolution	:	0.01 Hz
Accel/Decel Time	:	0 – 1800 s, adjustable
Overloadability (by load type)	:	
Constant Torque	:	150% of nominal current for 1min in every 5 mins.
Variable Torque (pump & fan)	:	No overloadability required
Ambient Temperature	:	40 °C, for higher temperatures see below
Installation Altitude	:	1000 m, for higher altitudes see below
Max. Relative Humidity	:	95 %, non-condensing. In presence of corrosive gases, the max. relative humidity is 60 %
Max. Corrosion Level of the Cooling Air	:	
Chemical Gases	:	IEC 721-3-3, class 3C2
Solid Particles	:	IEC 721-3-3, class 3S2
Max. Vibration Level (IEC 68-2-6):		
2 to 9 Hz	:	0.3 mm
9 to 200 Hz	:	1 m/s^2
Main Protections	:	Overcurrent, short circuit, input/output phase loss, motor overload and underload, over/under- voltage, overspeed, overtemperature, motor stall, other internal fault.

The VSD shall be able to give a 100 % output current continuously in the above specified conditions. In order to ensure that the drive can provide the required output current in the specified ambient conditions, the Manufacturer shall inform the required derating, if the ambient temperature given in the project-specific specification is higher than 40 °C or if the installation altitude is more than 1000 m above the sea level. The derating factor shall be specified so that neither the lifetime of the VSD nor the unit's performance, overloadability included, nor the reliability of the VSD shall suffer.

Storage conditions (in the protective package):

Ambient Temperature	:	- 40 to +70°C
Corrosion Level of the Cooling Air	:	
Chemical Gases	:	IEC 721-3-3, class 1C2
Solid Particles	:	IEC 721-3-3, class 1S3
Max. Vibration Level (IEC 68-2-6)	:	
2 to 9 Hz	:	1.5 mm
9 to 200 Hz	:	5 m/s^2
Shock (IEC 68-2-29)	:	max. 100 m/ s^2, 11 ms
Free fall	:	250 mm for weight under 100 kg 100 mm for weight over 100 kg

3.2 VSD Accuracy

The VSD shall have a minimum speed control accuracy of ± 10% of the nominal slip of the motor, without a pulse encoder feedback. In practise, this means e.g. for a four-pole, 50 Hz motor with a 45 rpm slip speed, an accuracy of ±0.3 % of the motor nominal speed. The VSD shall be capable of a dynamic accuracy of at least 0.4 %sec. without additional options. If this accuracy is not achieved without a speed feedback, the Manufacturer shall specify the accuracy that can be reached and if required, a pulse encoder with adequate control devices shall be included in the motor unit at the VSD Supplier's expense. The dynamic accuracy means the drive's capability to response fast in a dynamic situation, for example, if the load changes. It is measured by the change of speed and time, i.e. how long it takes to recover to the reference speed.

3.3 Starting torque and torque step rise time

Constant torque applications: The Starting Torque of the Motor unit without a pulse encoder feedback shall be at least 150 % of the rated Motor unit torque.
Variable torque applications: The Starting Torque of the Motor unit without a pulse encoder feedback shall be at least 100 % of the rated Motor unit torque

In case of need of fast torque rise time, the torque step rise time from 10 % to 90 % of the full nominal torque should be less than 5 ms, when the motor is fully magnetised. If the motor mechanical time constants are longer than that, the torque step rise time should be according to mechanical time constant.

3.4 Quality assurance and warranty

Every VSD has to be tested functionally. The inverter part of the VSD or each inverter module at least has to be tested by running it with a motor at full nominal load. A test report of the tests made has to be included with the VSD.

The warranty period of the VSD has to be a minimum of 24 months from the date of delivery or 12 months from the date of commissioning, whichever comes first.

4. Enclosure and mounting

The VSDs up to 75 kW in 400 V and 690 V or 90 kW in 500 V, can be installed separately in drive modules. There should be a possibility for flange mounting, to provide for cases, when the drive is installed in a cabinet and to enable installation of the heatsink outside the cabinet.

The VSD shall be equipped with fuses and a main circuit switch must be available either as standard or, at least, as an option. The switch shall be equipped with a door interlocked handle, padlockable in the open position. Input fuses shall be of semiconductor type, and their characteristics co-ordinated with the drive's electronic protection circuits so that they do not blow from normal output faults such as an overcurrent fault. The Control Panel of the VSD shall be accessible for programming and controls with the main door closed. The whole assembly shall be implemented with a strict consideration of the EMC Compatibility and Regulations as described further in this specification.

Panel Design Specs:

Standards	:	IEC 439-1, EN 60439 & VDE660 Part 500.
Protection Class	:	IP21 or better
Cabinet access	:	From front
Cable entry and exit	:	Bottom entry as standard. Both bottom and top entry have to be possible.

5. User interface

5.1 General

The user interface shall be similar throughout the power range to avoid confusion amongst the users and need for training in several different units.

5.2 Inputs and outputs

The following standard Inputs and Outputs at least shall be provided, to be used in interface with the control system:

Analog Inputs	:	1 x Programmable differential voltage input 0(2) - 10V 2 x Programmable differential current input 0(4) - 20mA
Analog Outputs	:	2 x Programmable current outputs 0(4) - 20mA
Digital Inputs	:	6 x Programmable Digital Inputs, optoisolated, common or separate ground
Relay Outputs	:	3 x Programmable Digital outputs with a changeover dry contact

All the control terminals shall be clearly marked.

The following functions at least shall be available via the IOs:

Input

Analog
- Speed reference
- Torque reference
- PID-control feedback (actual value)
- Correction signal to reference

Digital
- Start
- Stop
- Forward/reverse
- Pre-programmed constant speeds
- Speed up / down (motor potentiometer)
- Start and stop from 2nd source

Output

Analog
- Motor speed
- Motor torque
- Motor current
- Output frequency
- Output voltage
- Output of the process PID controller
- Control deviation of the PID controller
- Actual value of the PID controller
- Process speed

Relay
- Fault
- Running
- Ready
- Rotation direction
- Fault/warning
- Warning

Selection of acceleration / deceleration ramp
Selection of user macro
Run enable
Selection of control place
Fault reset

Stall fault or warning
VSD temperature fault or warning
Motor temperature fault or warning
Speed or torque limit reached
Motor magnetised
Controlled via serial communications

5.3 Serial communications

The VSD shall as standard have a provision for communication with PC software tools. In addition, the following serial communication protocols at least shall be available as option: Modbus, Modbus+, Interbus-S, Profibus DP, LONWORKS and DeviceNet. It shall be possible to add the serial communication later.

5.4 VSD keypad

The VSD shall have a detachable keypad with alphanumeric operating display for programming and controlling purposes. The displayed messages shall be in user friendly, descriptive text. Coded messages are not acceptable. Parameter setting shall be possible by using the keypad.

Parameter setting shall be easily accessible and user friendly with actual text messages. Password protection shall be provided to avoid unauthorised tampering with the set parameters. It shall be possible to read and write the set parameters with the help of the control pad, enabling thus copying of parameters between the VSDs of a similar application, to save time during the commissioning and to avoid mistakes. The VSD shall have a local lockout to prevent accidental transfer from remote to local.

Direct keypad entry shall be provided to observe the following actual parameters. Any three of the following parameters or actual values shall be selected to be always displayed.

- Input Voltage
- Input Frequency
- Output Voltage
- Output Frequency
- DC Bus Voltage
- Output Power
- Output Torque
- Output Current
- Motor Speed
- Process Speed

The following parameters shall always be displayed during normal operation.

- Speed Reference
- Run / Stop / Fault
- Remote / Local

The VSD shall have self-diagnostic properties to display faults and warnings as they occur and be able to store at least 15 previous faults into the fault memory. The fault memory shall be accessible by PC maintenance tools.

The following drive control functions at least shall be available from the keypad:

- Run
- Stop
- Local / Remote selection.
- Forward/Reverse (if function enabled)
- Accelerate (manual/mode)
- Decelerate (manual/mode)
- Parameter setting

- Scrolling & Viewing through Actual values

5.5 Application programming

The VSD shall be designed for both simple and the most complicated applications, yet it shall be user friendly. The VSD shall have built-in application macros, to allow selection of the range of pre-programmed control configurations and further, the VSD shall enable storing of two customer modified macros at least, to suit the specific application. It shall be possible to reset the parameter settings back to the original macro settings through the keypad. The parameter readouts shall be in text format and not coded.

5.6 PC Tools

The VSD Supplier shall have a Windows based PC software available for monitoring and controlling the VSDs, and the software shall be offered as an option. The software shall be supplied with the necessary hardware and a provision for connecting a PC with the VSD. It shall be possible to set and modify parameters, control the drive, read actual values and make trend analysis using the software.

6. Software features

6.1 Power loss ride-through

The drive shall have a power loss ride-through capability. This means that the drive controls should stay alive during a power loss by means of the energy stored in the load. The ride through time shall be the longer the higher the kinetic energy of the load is. The motor shall be magnetised as long as there is kinetic energy in the system.

6.2 Flying start

The drive shall have a built-in Flying Start feature. This feature will allow a Motor unit which is still rotating, to be restarted without first stopping it. The VSD shall restart the motor from the rotating speed and then reaccelerate to the speed indicated by the speed reference signal. The Flying Start feature shall be available in both directions, to be able to start the drive in the required direction regardless of the rotation direction of the motor.

6.3 Flux optimisation

The VSD shall have a built-in automatic Flux Optimisation function. The Flux Optimisation function minimises the sum of the magnetising current and the load current so that the drive can still follow the given reference. This feature reduces energy consumption and motor noise when driving at less than the nominal load.

6.4 Flux braking

There shall be a possibility for Flux Braking, where VSD increases the motor magnetisation to dissipate the extra energy in case of need for small braking power. It shall be possible to use the braking to decelerate the motor from one speed to another – not only for stopping the motor.

6.5 Critical speed jump-over

The VSD shall have programmable skip speeds to jump over critical resonance speeds. If the speed reference is in the critical speed area, it is ignored and the latest speed reference is maintained. Three programmable critical speeds at least shall be available.

6.6 Current/speed limiting

In case the acceleration or deceleration ramps are too fast for the drive capacity, the drive shall be able to automatically reduce the ramp to prevent tripping. Also, in case of transient overloads the drive shall automatically reduce speed to prevent an overcurrent trip, if the drive capacity is not sufficient to handle the load.

6.7 PID-controller

The drive shall have a built-in PID-controller for control of the customer process.

6.8 Restart

In the event of a fault trip due to overvoltage, overcurrent or loss of analogue signal, the VSD shall be programmable to attempt an automatic restart. For safety reasons, the maximum number of attempts shall be five (selectable) within a short time. If the fault does not clear after the attempts, the drive shall lock out.

7. Environmental effects

7.1 Harmonic Distortion

The VSD shall have built-in AC or DC chokes to minimise the Total Harmonic Distortion (THD). The THD of the unit for current has to be less than 50% in a supply network with a short circuit ratio (Rsc) of 300 (i.e. the ratio of the supply network's short circuit current to the unit's nominal current). If the supply voltage is 440 V or higher, the THD value has to be less than 55%. However, the VSD Manufacturer shall submit to the contractor the VSD Harmonic spectrum for the project-specific supply network. The spectrun shall be used in the design of appropriate harmonic filters, if required by the Customer. The single harmonics shall be presented up to 25^{th} harmonic and the THD has to be calculated taking into consideration harmonics up to 40^{th} harmonic.

7.2 EMC Regulations and Compatibility / C-Tick

The supplied VSDs shall carry the CE mark (or C-Tick in Australia) indicating that they comply with the essential requirements of the relevant EU directives (or C-Tick requirements in Australia). The VSDs shall meet the requirements set in EN 61800-3 for Industrial Low-Voltage Networks. If the project-specific specification states that the requirements for Public Low-Voltage Networks stated in EN 61800-3 must be met, the Supplier shall be able to provide such units at least up to 75kW in earthed networks. If separate EMC filters are required, they shall be of built-in type.

A detailed description and other directions to maintain the EMC Compatibility during the installation of the VSD and associated field cables and connections, shall be given by the Supplier in conformance with the EMC Directives or C-Tick. The Contractor shall follow the directions during installation, in order to achieve attenuation of the RFI.

7.3 Audible Noise

The full load audible noise of the frequency converter shall not exceed 70 dB(A) in 200 kW applications and below. Above 200 kW, the full load audible noise shall not exceed 78 dB(A). If the frequency converter is installed in a cabinet and requires a separate cooling fan, these limits also include the noise of the additional cooling fan. This requirement is made to keep the electrical room quiet so that it is not necessary to use hearing protection. The audible noise of the motor should also be minimised. For that purpose the switching frequency of the frequency converter shall be at least 2 kHz throughout the power range.

7.4 Efficiency

The full load efficiency of the VSD shall be at least 98 % including all the additional equipment which is needed to meet this specification.

GS.1.29 **SITE TESTS**

After completion of erection, cabling and field wiring, the contractor shall set all overloads, protection devices etc. and shall again carry out a full functional test to prove the correct operation of the entire MCC, including the simulation of all remote devices. A signed compliance certificate by the Contractor's accredited person for the MCC and its installation shall be handed over to the Employer's Representative on Completion.

The tests shall be witnessed by the Employer's Representative and shall be recorded in triplicate on approved test forms.

GS.1.30 **INSTALLATION OF MOTOR CONTROL CENTRES**

The contractor shall make it his responsibility to furnish the switchboard manufacturer with all the relevant information in respect of the accommodation to be provided, including cable trenches and ducts etc.

Where possible, the largest number of cubicles or panels should be installed intact, to avoid assembly on site, provided space and handling facilities and conditions do not lead to damage of the unit.

The contractor will advise the manufacturer which of the cables enter or leave from the top or bottom of the MCC.

GS.1.31 **DRAWINGS, EMPLOYER'S REPRESENTATIVE'S APPROVAL, GUARANTEES**

CAD generated drawings of the equipment showing full details of layout and proposed wiring system and equipment offered shall be submitted for approval to the Employer or his Representative prior to manufacture. The drawing must include part numbers and manufacturers of all plant and equipment.

The Employer's Representative shall also be advised when the board are being manufactured and when they will be ready for inspection at the works, Equipment which is despatched to the site without the authorization of the Employer or his Representative may be rejected and all costs incurred in having it returned to the factory, where necessary, and any liability for delays, will be for the contractors account.

The contractor will issue to the Employer's Representative one set of sepias and 3 copies of drawings of the "As Built" equipment which has been installed and connected on site after the draft copy has been approved. Handbooks, spares lists and maintenance instructions etc. will be issued to the Employer's Representative in triplicate at the time of handing over the equipment before the guarantees period commences.

The manuals shall be comprehensive and to include all equipment supplied. A 12 month guarantee shall cover the sheet metal enclosures and all the equipment installed therein against fault workmanship and materials. The guarantee period shall begin from the date the MCC's are completely installed and accepted by the Employer's Representative. Fair wear and tear of equipment will be excluded from the guarantee.

GS.1.32 **COMPLETION**

Prior to the handing over of the boards or panels and the associated electrical installation, they shall be rendered completely free of all dust or rubbish that may have collected during installation and building operations, and finished surfaces shall be made good where necessary, using the identical paint finishes from the same batch, as at the time of manufacture.

The MCC's shall be vermin proofed. Similarly, all cable trenches will be thoroughly cleaned out and all covers fitted before the work will be considered as complete. All labels will be correctly engraved and fixed to panels and cables as specified before the work can be considered complete.

All cable sleeve or other openings shall be closed or patched up and made good: Cable sleeves shall be sealed using an approved expanding foam sealer and neatly trimmed.

GS.1.33 **SUGGESTED SUPPLIERS**

Refer to Annexure A.

GS.1.34 **MANUFACTURERS**

Manufacturers may be considered by the Employer's Representative, but only if they have a proven track record of manufacture to SANS 1473/SANS 60439.

The tenderer shall ensure that copies of these Standard Specifications, Detailed Specifications, layout drawings and single line diagrams if available shall be provided to the manufacturers to ensure that they make full allowance for all requirements in their pricing.

ANNEXURE A

SCHEDULE OF RECOMENDED EQUIPMENT. THE TENDER MAY, HOWEVER, OFFER ALTERNATIVES

Soft starters	ABB
Variable speed drives	ABB
Circuit Breakers	Merlin Gerin, ABB, CBI
Contactors, indication lamps	ABB, Telemecanique,
Relays, fuses, motor protection relay	Omron, ABB,Finder
Control switches, selector switches	Krause and Naimer, ABB, Telemecanique, Moeller
Electronic Motor Controller	ABB UMC22-FBP,Omron SEK
Ammeter, voltmeter, current transformer, operations counter, hour meter.	Hartmann and Braun
Cables, Wire	Aberdare
HRC fuses and holders	G.E.C.
DC Power Supplies	Meanwell Ad-155B
Electrically operated solenoids	Festo, Asco, Burkert
Level Control	Siemens Milltronics Multiranger MR200 DP 6R, Siemens stainless steel echo max transducer brackets FMS310.
Surge Arrestors	Dehnguard 275 and 1 No. DehnGap
Power supplies	Siemens / SITOP series
Relays	Omron, ABB
Terminal relays	Weidmuller, Klippon, Phoenix Contact
Electrical motors	WEG,ABB
Emergency stop stations	Cutler Hammer, ABB
Circuit breakers	ABB, Schneider, M&G
Fuse switches	ABB Stromberg
Terminals	Klippon, Phoenix Contact
Cable glands	Pratley Envirogland
Junction boxes	York enclosures
Power monitor	Schneider , ABB
Open channel measurement flow meter	Siemens Milltronics Multiranger MR-200 DP 6R
Radar level meter	Krohne, VEGA, Siemens
Magnetic flow meter	Safmag, Siemens, Krohne, Endress & Hauser
Other flow meters	Siemens, Fuji, Krohne, Endress & Hauser
Flow switches	EGE
Pressure transmitter	Wika, Siemens
Differential pressure transmitter	Wika, Siemens
Chlorine gas leak detectors	Siemens, Grundfos
Residual chlorine meter	Siemens, Grundfos

Dissolved oxygen meter	Hach LDO type
Turbidity meter	Hach, Endress & Hauser
Temperature measurement	Wika, Siemens
Pressure gauges	Wika ,Siemens
Air flow meters - Thermal resistance type	Endress & Hauser
Proximity switch	efector (Shorrock Automation)
Solenoid operated valves	Bürket
Surge protection	Surgetek : BCT BE24 (signals) DEHNguard 275 (line) DEHNgap B (neutral) Phoenix Type TT-2-PE- 24VDC
	DehnVentil 255 - Mains
Loop splitters	Omniflex type LPI/LPS
UPS	APC
Industrial Ethernet network switch	Unmanaged - Hirschmann Managed - Hirschmann
Pneumatic actuators	Festo, Biman
Electrical Valve actuators	Aumanat
Pipework Coating	Plascoat PPA 571 Aqua
Non-Shrink Grout	Pro-Struct 531-MCI

ANNEXURE B

COMPULSORY DATA PACK FOR MCC

1) Drawings 3 sets
2) Drawings electronic format CD as built
3) Factory Routine Test Certificates (SANS 1473-1)
4) Site Test Certificates
5) Certificate of Compliance
6) Maintenance Manual
7) Technical Specifications
8) All Electronic and Electrical Manuals
9) Partial Type test certificates for MCC over 10Ka.
10) Paint Thickness certificate.
11) All programmable parameters of all electronic/instrumentation equipment, overload settings, soft starters, shall be supplied.
12) An electronic copy of the PLC program installed in the plant
13) A schematic of all cable routes and joints of all cables. This should show the position of all cable markers installed.
14) A life cycle letter from the manufactures of all electrical and electronic equipment. (Soft Starter/VSD). Contact details of all agents/ sole suppliers of all electrical and electronic equipment for after sales service and back up.

ANNEXURE C

SPECIFICATION FOR THE INSTALLATION OF LIGHTING

This is the Standard Specification for the Installation of Lighting at the pump stations. All lighting installations shall comply with the Occupational Health and Safety Act (85 of 1993) and the SABS Wring Codes of practice 01042. All lighting offered shall be of the latest energy efficient lighting and control. All lighting shall be of the Eskom approved energy saving LED type and shall match or exceed the existing lux levels.

The installation shall be done in the manner outlined below in the following areas.

PANEL ROOM, OUTSIDE, DRY AND WET WELL LIGHTS

Type of light Fixture
Five Foot (5ft) double dust and hose proof light fittings/250MV.

Method of Mounting
All light fittings shall be mounted with 8mm x 40mm stainless steel Double Wedged anchor Bolts.
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Method of Termination:
Each light fitting shall have a 500mm, two core plus earth cabtrye. Tail piece that is to be terminated in a four way round junction. Box (preferred CCG No1); having a rating of no less than IP65.The strip connectors shall be rated at 30amps for ease of connection and disconnection.

Electrical Circuit
The lighting circuit in each location shall have its own circuit breaker and must be labelled.

Light Switch
Each location shall have its own weather proof light switch in its own enclosure and be labelled. This should mounted at the main door entrance of the panel room or as instructed by the Engineer.

Mounting Height
The light fittings shall be mounted at a height that is maintenance friendly. If a ladder is to be used it shall be of a maximum of a 5ft ladder. Lights in sumps must be mounted out of the flood zones.

General Installation of Conduits
The use of PVC conduit is only permitted if it is installed in such a manner that it is not exposed to direct sunlight. Hospital or spacer bar saddles shall be used to fix the conduit onto the wall. Bosal pipe must be used for outside installations.

Outside Lighting
These lights shall be controlled via a timer.