ANNEXURE B: PARTICULAR EC&I SPECIFICATION

CONTENTS

1. DETAILED ELECTRICAL SPECIFICATION

1.1. ELECTRICAL SCOPE

The electrical installation scope of works shall include the following:

(a) 400VAC Distribution Board (DB)

(b) Supply to ventilation fans

(c) Supply to electric actuated valves

(d) Power outlets

(e) Lighting

(f) Smoke and fire detection system vendor packaged unit

(g) LV cables

(h) Cable support systems

(i) Earthing and bonding

(j) Testing and commissioning of the electrical installation.

(k) Certificates of compliance

(l) As-built drawings

(m) Operation and maintenance manuals

(n) Training

1.1.1. Electrical Works Compliance

The electrical works shall be provided in accordance with the following Technical Data Sheets (See **Annexure B** for details):

(a)	DS-EE-0010	Distribution Boards and Kiosks
(b)	DS-EE-0011	LV Cables
(c)	DS-EE-0012	Cable Supports
(d)	DS-EE-0013	Small Power
(e)	DS-EE-0014 A-	Lighting
(f)	DS-EE-0014 B-	Luminaire Schedule
(g)	DS-EE-0026	Electrical Actuators
(h)	DS-EL-0001	Fire Detection

(i) The supplier technical details shall comply with the data sheet above, any deviations and/or alternative offers to be provided in writing to the Engineer for approval.

The electrical works shall be provided in accordance with the following engineering standards (these form part of the specification along with this document which describes the detail requirements of this project), See **Annexure B** for details:

(a)	SPE-EE-0010	LV Switchgear & Controlgear Assemblies
(b)	SPE-EE-0011	LV Cables
(c)	SPE-EE-0012	Cable Support Systems
(d)	SPE-EE-0013	Wiring and Outlets
(e)	SPE-EE-0014	Lighting
(f)	SPE-EE-0020	MV & LV Earthing
(g)	SPE-EE-0026	Electric Valve Actuators
(h)	SPE-EL-0001	Fire Detection and Alarm Systems

The electrical works shall be provided in accordance with the following attached schedules (See **Annexure B** for details):

(a)	504373_DB-CAISSON_MES	Motor and Equipment Schedules
(b)	504373_DB-CAISSON_CAB	Motor and Equipment Cable Schedules

These tables and schedules depend on the actual mechanical equipment offered by the Tenderer. The Tenderer is responsible for pricing any changes to the electrical design that are caused by his/her selection of mechanical equipment.

1.2. LV DISTRIBUTION BOARD

The work under this section shall comply with:

Technical Data Sheet: DS-EE-0010A	Distribution Boards and Kiosks
Engineering Specification: SPE-EE-0010	LV Switchgear & Controlgear Assemblies

1.2.1. Caisson Gate Distribution Board

(a) An outdoor floor mounted 400VAC LV distribution board (DB) shall be installed above the caisson gate top deck level to supply power to all equipments associated with the caisson gate operation.

(b) The Sturrock dry dock have existing distribution kiosks on both sides of the caisson gate on land which will supply power to the caisson gate during operation. Only one existing kiosk will supply power to the caisson gate at a time depending on which kiosk is available.

(c) The DB shall have 3 mechanically interlocked incomers such that only 1 incomer is ON at a time.

(d) 2 DB incomers cables shall be equipped with 63A 5 pin 3-phase male industrial socket outlets as per DB single line diagram drawing , to fit into the existing kiosk's 63A pin 3-phase female industrial socket outlets, which will supply power to the caisson DB.

(e) A 3rd DB incomer shall be for a portable back-up generator to supply power to the DB during mains power outages. The generator incomer shall be connected to a generator connection box equipped with a 63A 5 pin 3-phase female industrial socket outlet as per DB single line diagram attached to the project specification.

(f) The distribution board shall consist of the following components:

i. A mains incomer section with 3 incomers mechanically interlocked to only switch ON 1 incomer at a time. It shall be possible to switch all 3 incomers OFF.

ii. A section with feeders to:

1. Electric actuated valves
2. Ventilation fans
3. Lights
4. Power socket outlets
5. Fire detection control panel
6. Control supply transformer (feeding UPS in local control console)

(g) When connected to the existing kiosk's 63A 5 pin 3-phase socket outlet, the DB assembly shall be earthed to the relevant kiosk's earth via the 63A 5 pin 3-phase socket outlet's earth.

(h) The DB shall have a legend sheet on the inside with the following information of the equipment fed from the DB:

(i) Tag number

(ii) Description e.g. Light Circuit 1

(iii) Amp rating

(i) Witnessed factory and site acceptance testing by 2 Engineers shall be carried out by the Contractor. Travel costs for the persons shall be included in the tender pricing for the DB panel.

(j) The in-house factory acceptance test (FAT) documents shall be provided to the Engineer prior to the witnessed FAT.

1.3. PORTABLE GENERATOR CONNECTION BOX

The work under this section shall comply with:

Technical Data Sheet: DS-EE-0010B	Distribution Boards and Kiosks

1.3.1. General

(a) The Contractor shall provide an outdoor pedestal mounted Generator connection box as per the attached DB single line diagram.

(b) The Generator connection box shall be equipped with a 400VAC 3 phase, 5 pin female industrial socket.

(c) The Generator connection box shall be installed above the caisson gate top deck level to fast connect a portable generator for back-up power.

1.4. SMOKE AND HEAT DETECTION SYSTEM VENDOR PACKAGED UNIT

The work under this section shall comply with:

Technical Data Sheet: DS-EL-0001	Fire Detection and Suppression
Engineering Specification: SPE-EL-0001	Fire Detection and Alarm System

1.4.1. General

(a) Smoke and heat detector shall be a vendor packages unit with sensors installed in all dry air spaces and control panel installed above the caisson gate top deck level.

(b) Smoke and heat detection shall alarm at the smoke and heat detection vendor packaged control panel, local control console, local HMI, dock master's SCADA as well as sound a siren and strobe located inside dry air spaces and above caisson gate deck.

(c) All relay outputs on the Fire Panel required to accomplish this external alarm functionality shall be provided.

1.4.2. Design

(a) The Contractor shall be responsible for the detail design of the fire detection system, based on the product offered.

(b) The Contractor shall employ a SAQCC Level 4 designer to design a fire detection system for the Engineer and Employers approval. At least two iterations of design review meetings with the Engineer and Employer shall be allowed for.

1.4.3. Scope

(a) The installation shall include the supply, installation and commissioning of the following:

- (i) New analogue addressable fire detection control panel shall be installed within the control panel.
- (ii) Optical smoke / heat detectors for all areas inside the caisson where operators can be walking or working.
- (iii) Combination siren and strobe units below and above deck.
- (iv) Red break-glass units.
- (v) Fire resistant wiring as required by regulations – FR120 according to BS 7629, Electric cables – Specification for 300/500V fire resistant electric cables having low emission of smoke and corrosive gases when affected by fire.
- (vi) Input / Output units (min 3) for the fire panel.
- (vii) The system shall have the capability of connecting to the SCADA/Telemetry or fire department.
- (viii) Conduit wire ways as required.
- (ix) Labelling
- (x) Training and instruction manuals.

(b) The fire detection system installed within the caisson shall be installed according to the requirements of a system category L1 according to SANS10139:2012 Fire detection and alarm systems for buildings – System design, installation and servicing and SANS 10400-T-2020 Fire Protection..

(c) The Contractor shall ensure that the analogue fire detection panel has sufficient inputs to accommodate the fire detection system within the caisson.

(d) For the first knock, an alarm shall be shown on the control desk HMI and SCADA system. On the second knock the siren and strobe lights shall be activated.

1.5. ACTUATED VALVES

The work under this section shall comply with:

Technical Data Sheet: DS-EE-0026	Electric Actuators
Engineering Specification: SPE-EE-0026	Electrical Valve Actuators

1.5.1. General

(a) The air valves for the caisson gate shall be open/close actuated valves.

(b) The sea water valves for the caisson gate shall be modulating actuated valves.

(c) The actuated valves shall be provided with built-in circuitry and control circuitry.

(d) The actuated valves shall be of the battery backed-up fail close type in case of power failure.

(e) The actuated valves back-up batteries shall be sealed lead acid type batteries that require no maintenance. On loss of power the batteries shall supply 24VDC power to close the valves.

1.5.2. Installation

(a) A 400VAC feeder circuit shall be provided from the caisson gate DB for each of the actuators as indicated on the caisson gate DB single line diagram (See Annexure H for book of drawings).

(b) Push buttons and Indicator lamps are required for control of the actuators at the local control console (see electronic section) and as per local control console general arrangement drawing (See Annexure H for book of drawings).

(c) Field/local control shall be possible at the actuators by means of on-board integral push buttons/switches at the actuators.

(d) The operations personnel shall be able to open or close the valve remotely by means of the HMI or local control console pushbuttons.

1.6. VENTILATION FAN

1.6.1. General

(a) A 230VAC single phase feeder circuit shall be provided from the caisson gate DB for each of the ventilation fans as indicated on the caisson gate DB single line diagram drawing (See Annexure H for book of drawings).

(b) The forced ventilation shall be for the dry air spaces to all fresh air and sufficient oxygen in the caisson gate dry air spaces during operation and maintenance.

(c) During fire or smoke detection alarm, the ventilation fans shall automatically be switched off to prevent oxygen in the dry air spaces that might aggravate any fires.

1.7. POWER OUTLETS

The work under this section shall comply with:

Technical Data Sheet: DS-EE-0013	Small Power
Engineering Specification: SPE-EE-0013	Wiring and Outlets

1.7.1. General

(a) All single phase switched socket outlets (IP66 or higher) installed inside the caisson gate dry air spaces shall be surface mounted as per power layout drawing (See Annexure H for book of drawings).

(b) Industrial 3-Phase switched socket outlets inside the caisson gate dry air spaces shall be 32A 5-Pin IP66 (or higher) and shall be surface mounted as per power layout drawing (See Annexure H for book of drawings).

(c) Industrial 3-Phase switched socket outlet on the side of the caisson gate DB shall be a 32A 5-Pin IP66 (or higher) and shall be mounted as per DB-Caisson general arrangement drawing (See Annexure H for book of drawings).

(d) Industrial 3-Phase switched socket outlets for the DB incomers shall be 63A 5 pin IP66 (or higher) as per DB single line diagram drawing (See Annexure H for book of drawings).

(e) Corrosion resistant switched socket outlet shall be installed.

1.8. LIGHTING (CAISSON GATE INTERIOR AND EXTERIOR)

The work under this section shall comply with:

Technical Data Sheet: DS-EE-0014A	Lighting
Technical Data Sheet: DS-EE-0014B	Luminaire Schedule
Engineering Specification: SPE-EE-0014	Lighting

The supplier technical details shall comply with the data sheet above, any deviations and/or alternative offers to be provided in writing to the Engineer for approval.

1.8.1. General

(a) LED based light fittings shall be installed as per lighting layout drawing (See Annexure H for book of drawings).

(b) Selected battery backed-up emergency light fittings shall be installed as per the lighting layout drawing.

(c) The light fittings shall be corrosion resistant and with minimum ingress protection of IP66 or higher.

(d) Internal and exterior lighting shall be controlled by means of light switches as per the lighting layout.

(e) IP66 (or higher) corrosion resistant lockable light switches shall be surface mounted close to entrances and exits.

(f) Details of luminaires to be installed are supplied in the technical datasheets.

(g) Samples of all light fittings shall be delivered to the Engineer for approval before orders are placed

1.9. LV CABLES

The works under this section shall comply with:

Technical Data Sheet: DS-EE-0011	LV Cables
Engineering Specification: SPE-EE-0011	LV Cables

1.9.1. General

(a) The Contractor shall design detailed cable routes in collaboration with the Engineer and as per proposed cable route layout attached to the Specification. Detailed cable routes shall be submitted for the Engineer's approval prior to installation.

(b) The single line diagram and equipment cable schedule (See Annexure B for details) indicates the LV cables based on the Engineer's design.

(c) The actual cables shall be sized by the Contractor to power equipment offered by the Tenderer, with cable lengths measured following the Contractor's final approved cable routes. The cables selected shall satisfy the constraints specified by the Engineer in the attached cable schedule (See Annexure B for details) and suit the method of installation.

(d) LV multicore DB main incomer (from existing kiosks) cables shall be flexible PVC Nitrile trailing cables as per single line diagram drawing (See Annexure H for book of drawings).

(e) Flexible incomer cables shall be coiled at each end of the caisson gate in lockable cable storage boxes on caisson gate for storage when not connected to the existing kiosks.

(f) LV multicore feeder cables and portable generator incomer cable shall be copper conductor, PVC insulated cables with steel wire armouring as per single line diagram drawing (See Annexure H for book of drawings).

(g) Cables installed on cable ladders/trays shall be neatly installed and secured in parallel.

1.10. CABLE SUPPORTS AND CABLEWAYS

The works under this section shall comply with:

Technical Data Sheet: DS-EE-0012	Cable Supports
Engineering Specification: SPE-EE-0012	Cable Supports

1.10.1. General

(a) See Annexure H book of drawings for prosed cable route layout drawing.

(b) The contractor shall design a detailed cable route drawing detailing cable support and cableway layouts which will include layouts of cable ladders, cable trays, conduits and sleeves.

(c) Due to the corrosive environment, stainless steel cable ladders, trays, conduits and unistrat shall be neatly installed to support cables inside and outside the caisson gate.

(d) Power outlets cables and lighting cables shall be neatly installed in surface mounted stainless steel conduits.

(e) The Contractor shall ensure that the quantity of conduits and other cable supports into the caisson gate are adequate and locations of the conduits and other cable supports correspond to the locations of his/her equipment.

(f) All cable openings on the caisson gate structure shall be sealed with a sealable product like Roxtec sealing solutions or similar equivalent product to prevent water ingress into the caisson gate structure and cable ducts

1.11. LV EARTHING AND BONDING

The works under this section shall comply with:

Engineering Specification: SPE-EE-0020 – MV and LV Earthing

1.11.1. Earthing and bonding requirements

(a) All electrical and electronic equipment shall be earthed.

(b) Earth continuity conductors shall be provided with all the LV power cables to electrical equipment and as shown on the single line diagrams.

(c) Where no separate earth continuity conductor is shown on the single line diagram, the intention is that a spare core in the power cable shall serve this function.

(d) Earthing terminations shall be off Stainless Steel 316 material.

(e) The caisson gate shall be equipped with a main copper earthing bar located inside the caisson gate.

(f) All accessible extraneous conductive parts of electrical equipment/electrically-driven equipment shall be bonded in accordance with SANS 10142-1.

2. DETAILED ELECTRONICS SPECIFICATION

2.1. SCOPE

The electronic installation scope of works shall include the following:

(a) Local Control Console (LCC)

(b) Programmable Logic Controllers (PLC)

(c) Human Machine Interface (HMI)

(d) Uninterruptible Power Supply Units (UPS)

(e) Instrumentation

(f) Wireless Ethernet

(g) SCADA

(h) Reporting

(i) Remote Monitoring

(j) Programming

(k) Control, instrumentation and data cables

(l) Cable supports

(m) Earthing and surge protection of electronic equipment

(n) Functional Design Specification (FDS)

(o) Testing and commissioning

(p) Certificates of Compliance

(q) Instrumentation calibration certificates

(r) Operation and maintenance manuals

(s) Training

(t) As-built drawings

2.1.1. Electronic Works Compliance

The electronic works shall be provided in accordance with the following Technical Data Sheets (See **Annexure B** for details):

(a) DS-II-0001 Control, Instrumentation and Data Cables

(b) DS-II-0002 Control Panels

(c) DS-II-0004 Radio Telemetry

(d) DS-II-0005 SCADA

(e) DS-II-0007 Instrumentation

(f) The supplier's technical details shall comply with the data sheets above. Any deviations and/or alternative offers shall be provided in writing to the Engineer for approval.

The electronic works shall be provided in accordance with the following engineering standards (See **Annexure B** for details):

(a) SPE-II-0001 General Electronic Installations

(a) SPE-II-0002 Programmable Logic Controllers

(b) SPE-II-0004 Radio Telemetry

(c) SPE-II-0005 SCADA

(d) SPE-II-0007 Instrumentation

The electronic works shall be provided in accordance with the following attached schedules (See **Annexure B** for details):

(a) 504373_DB-CAISSON_I&CS Control and instrumentation cable schedule

(b) 504373_DB-CAISSON_IOLIST IO list

These tables and schedules depend on the actual equipment offered by the Tenderer. The Tenderer is responsible for pricing any changes to the electronic design that are caused by his/her selection of equipment.

2.2. GENERAL ELECTRONIC INSTALLATION

The works under this section shall comply with:

Technical Data Sheet: DS-II-0001 Control, Instrumentation and Data Cables

Engineering Specification: SPE-II-0001 General Electronic Installations

2.2.1. General

(a) The control architecture network diagram drawing and the control network layout drawing (See Annexure H for book of drawings) shows how the control and monitoring system of the caisson gate is connected.

(b) The caisson gate shall be automatically controlled by a PLC with the option of manual control. The automatic control shall not start a process but rather be interlocked with process steps to guide the operator to manually start each process. The Operator shall not be able to bypass or skip process step interlocks in automatic mode.

(c) The Contractor shall develop a detailed control system architecture and control network layout drawings for the caisson gate based on his/her offered equipment and submit a diagrammatic representation thereof to the Engineer for approval prior to detail design and purchase of equipment, manufacture and programming of the control and instrumentation system.

2.2.2. System Voltages

(a) 230VAC for DB contactor coils and DB controls

(b) 24VDC for PLC

(c) 230VAC UPS supply

(d) 230VAC/24VDC for UPS supply to instrumentation power as required

(e) 24VDC for digital inputs and outputs

(f) 4 – 20mA current for analogue instruments

2.2.3. Control Cables

(a) Control cables shall be provided as detailed in the control and instrumentation cable schedule attached to the specification. The Contractor shall however develop a final cable schedule and cable block diagram to suit his equipment offered under the tender and the Contractor shall be deemed to have allowed in his tender all control cabling required to complete the installation.

(b) Control cables shall be 600/1000V multicore standard copper conductors. PVC-insulated cables with galvanised steel wire armouring and PVC serving.

(c) All control cables installed outdoors shall be armoured regardless of installation in sleeving or conduits.

(d) All cable glands shall be resistant to corrosion and shall be of the Enviro-gland or approved equivalent type.

2.2.4. Instrumentation Cables

(a) Instrumentation cables shall be provided as detailed in the control and instrumentation cable schedule attached to the specification. The Contractor shall however develop a final cable schedule and cable block diagram to suit his equipment offered under the tender and the Contractor shall be deemed to have allowed in his tender all instrumentation cabling required to complete the installation.

(b) Instrumentation cables shall either be twisted pair or triad standard copper conductors, individually and overall screened, PVC-insulated with galvanised steel wire armouring and PVC serving.

(c) All instrumentation cables installed outdoors shall be armoured regardless of installation in sleeving or conduits.

(d) All cable glands shall be resistant to corrosion and shall be of the Enviro-gland or approved equivalent type.

2.2.5. Data Cables

(a) Data cables shall be provided as detailed in the control and instrumentation cable schedule (See Annexure H for book of drawings) and control architecture drawing. The Contractor shall however develop a final cable schedule and cable block diagram to suit his equipment offered under the tender and the Contractor shall be deemed to have allowed in his/her tender all data cabling required to complete the installation.

2.3. CABLE SUPPORTS AND CABLEWAYS

The works under this section shall comply with:

Technical Data Sheet: DS-EE-0012 Cable Supports

Engineering Specification: SPE-EE-0012 Cable Supports

2.3.1. General

(a) Control and instrument cables may be run on the same cable tray/ladder as power cables, except where electromagnetic interference may affect the instrumentation signals.

(b) Control and Instrumentation cables shall be installed at least 300 mm away from power cables. Where this is not possible, control, instrumentation and data cables shall be installed in dedicated cable conduits to reduce any interference.

2.4. INDUSTRIAL NETWORK INSTALLATION

The works under this section shall comply with:

Engineering Specification: SPE-II-0003 Industrial Network Installation

(a) The industrial network installation is depicted on the control architecture drawing (See Annexure H for book of drawings).

(b) The Contractor shall produce a detailed Control System Functional Design Specification (FDS) based on the approved design, explaining all interlocks and controls, for discussion and approval by the Engineer and the Employer as well as attend meetings with the Employer and the Engineer for discussion hereof. This shall also include the SCADA and HMI mimics.

(c) The Contractor shall allow for 5 iterations of the FDS after a fully comprehensive FDS (as per (d) below) has been submitted. This may include mimic workshops with the Employer to determine colour coding and mimic functionality.

(d) The contents of the FDS shall be as follows:

FDS CONTENTS	
1	Introduction
2	Control Philosophy
3	Control System (Overview)
	• Control Architecture • Control System Hardware • Control system IOs
4	Control System (Software)
	• Software structure • PLC function blocks and description • PID control logic • Alarm logic and management • Interlocks • SCADA

FDS CONTENTS	
5	Operation and Monitoring
	• Hardware and software • HMI • SCADA • Mimics and visualisation • Function block faceplates • Wireless Ethernet • Remote Monitoring • Reporting, trends and dashboards • Security and passwords
6	Appendices
	• Actuated valves and equipment list • Instrumentation list • I/O list • Alarm list • Interlocks list (safety and process)

2.5. LOCAL CONTROL PANEL

The work under this section shall comply with:

Technical Data Sheet: DS-II-0002	Local Control Panel
Engineering Specification: SPE-II-0002	Programmable Logic Controller

2.5.1. Programmable Logic Controller (PLC) Panel

Local Control Console

(a) The PLC local control console panel shall be installed above the caisson gate top deck level.

(b) The panel shall house the PLC, HMI, direct current (DC) power supplies, instrumentation distribution and UPS; and shall be lockable with a unique employee SAP number for access to operate.

(c) The PLC shall be programmed with process sequence interlocks for sinking and floating the caisson gate.

(d) The UPS, panel split unit AC, actuated valves, smoke/heat detection system and instrumentation associated with the caisson gate shall be interfaced and/or connected to the PLC for automatic control and monitoring purposes.

(e) See Annexure H book of drawings for a typical local control console panel general arrangement drawing.

(f) The price for the local control console panel shall be deemed to include for all mounting plates, DIN mounting rails, wire trunking, wiring, labelling, glands and internal peripherals.

(g) The enclosure shall be properly ventilated by split unit air conditioner to make sure the panel IP rating is not compromised. Cooling shall include adequate cooling for the UPS. Consideration shall be given to the corrosive air that will be supplied into the panel.

(h) A thermostat shall be installed inside the local control console to maintain a safe working temperature in the local control console and to safeguard against condensation and humidity in the panel.

(i) The panel shall be large enough to allow for all required equipment plus 20% spare physical space.

(j) Power distribution and instrument supply circuit breakers shall be located in the local control console panel.

(k) A separate protective earth bar and an insulated earth bar shall be supplied in the local control console panel.

Programmable Logic Controller Functionality

(a) The PLC shall be programmed to execute process sequence automatic operation of the caisson gate according to the Engineer's specified control philosophy.

(b) The PLC software developed under this contract shall remain open source (i.e. unlocked) and become the property of the Employer and shall be included on a USB flash disk and protected cloud based storage (that is accessibly by Employer) as part of the final Operational and Maintenance (O&M) manuals.

Inputs and Outputs

(a) The attached IO list for the PLC shall only serve as a guide to Tenderers, and the Contractor shall be responsible for determining and providing all the required I/Os including spares to provide the specified control and monitoring functions of his offered equipment.

(b) Digital input / output cards shall be 24 VDC and analogue input / output cards 4- 20mA current loops where signals from conventional process instrumentation are required.

(c) The input / output modules shall be provided with their own power supply independent from the CPU power supplies.

(d) The I/O list shall be finalised by the Contractor during the Contract and shall be submitted for approval to the Engineer before final design and programming of the PLC.

Uninterruptible Power Supply (UPS) (also applicable to SCADA UPS)

(a) The PLC shall be equipped with a high reliable, corrosion resistant UPS which shall provide power to the PLC, HMI and instrumentation during mains failure for the minimum period specified in technical data sheet DS-II-0002.

(b) The UPS batteries shall be deep cycle type batteries to allow for the deep discharge of the batteries without killing the batteries.

(c) An isolation transformer on the input side shall be included to ensure voltages remain constant when the neutral supply is cut during generator changeover.

(d) Adequate provision shall be made for ventilation of a UPS when it is installed in a local control console panel.

(e) The UPS system shall be tested on site and the Contractor shall ensure that the PLC and HMI shutdown and restart automatically without losing any information or requiring operator intervention should the UPS standby period expire before portable standby generator power is available.

(f) The sizing (load calculation) of the UPS loads shall be provided to the Engineer for approval. The UPS shall be sized to handle the full load (no diversity in calculation) + 30% spare. After installation, the loading on the UPS shall be tested to confirm the 30% spare capacity.

Human Machine Interface (HMI)

(a) A colour touch screen graphical HMI shall be provided on the local control console panel. The HMI shall be configured to provide the operator with equipment control and status information, alarm lists, graphical trends and limited data logging.

(b) The HMI shall also allow control parameter changes to the PLC, which shall be password protected and logged. Operator actions, selections or setting updates described in the control philosophy shall be possible via the HMI interface.

(c) The HMI shall be configured with a simple default graphic display (mimic) showing all relevant equipment of the caisson gate, its status and instantaneous and totalised instrument readings.

(d) Status shall be indicated by different state colours (such as white for ready, green for running, amber for tripped and red for 'E-stop' or other fault states).

(e) An alarm page shall be provided showing all outgoing and incoming alarms. Alarms shall be stored in a first in first out file stored in the HMI memory. It shall be possible to scroll backward and forward in the alarm list.

(f) Allowance shall be made for the ventilation and mounting angle in accordance to the HMI supplier requirements.

2.6. SCADA

The works under this section shall comply with:

Technical Data Sheet: DS-II-0005	SCADA
Engineering Specification: SPE-II-0004	SCADA

2.6.1. General

(a) A new standalone SCADA system, shall be installed in the existing Dock Master's office complete with a rack mounted server and historian, UPS, a printer, 2 desktop computers, mouse and keyboards.

(b) The SCADA shall allow monitoring only of the caisson gate.

(c) All information from the caisson gate shall be available at the SCADA and stored for future view of events.

(d) The SCADA mimics shall be reviewed by the Engineer before these are presented in the control system FAT or are implemented on site. Tenderers shall allow for at least five iterations in the design and review of the SCADA design and mimics.

(e) The Contractor shall allow for a complete control system software FAT for at least five persons as part of the software development.

(f) The Contractor's System Integrator (SI) shall involve the Original Equipment Manufacturer (OEM) for a consultation and specification meeting with the Engineer and Employer to confirm the SCADA architecture before any engineering commences. The OEM shall further be involved for fault finding and pre-commissioning testing on site.

(g) The Contractor shall allow for at least one scoping meeting between the Contractor, the SI, the OEM, the Engineer and the Employer to finalise the scope and discuss the latest technology developments.

2.6.2. SCADA Hardware

(a) The Contractor shall provide the SCADA hardware as per control architecture network diagram, control network layout diagram drawings and SCADA technical data sheets attached to this specification.

2.6.3. SCADA Software

(a) The SCADA package shall be the latest licence available and shall offer remote view (including on mobile platforms) functionality.

(b) The SCADA package shall be able to integrate seamlessly with the PLC. The SCADA package shall be an industrial recognised SCADA software package.

(c) The Contractor shall provide a mobile platform version of the SCADA (including all licensing requirements) for mobile users and maintenance personnel; at least 5 mobile licenses.

(d) It shall be the Contractor's responsibility to derive all tags necessary for the SCADA system to display, monitor, log, trend and record all information from the PLC.

(e) The license shall be sufficiently sized to have at least 50% spare tags after commissioning.

(f) The Contractor shall provide all server and computer operating systems as well as anti-virus software.

2.6.4. Remote Monitoring

(a) The Contractor shall set up a web based remote monitoring of the SCADA and historian for the use of a mobile (ruggedised) tablet.

(b) An intelligent remote access and networking device that serves as an endpoint for secure remote connections, shall be set up for the remote access of site data by the Dock master or operations manager. The supervision network shall be securely accessed through this device via an encrypted VPN connection.

(c) The intelligent remote access device shall provide a VPN throughput of up to 15 Mb/s. The VPN authentication shall be provided via an access key or soft key licence that is linked to that specific intelligent remote access device only.

(d) The Contractor shall allow for 1 master key license and at least 2 Softkey licenses that can be used by a Tablet or PC.

(e) The intelligent remote access device shall provide a built-in firewall (NAT) to enhance security of the site.

(f) The intelligent remote access device shall have a web interface and PoE functionality.

(g) The Contractor shall provide all necessary accessories such as modem, antennas, mountings and wiring required by the intelligent remote access device. The device and ancillaries shall be installed in the dock master's office

2.6.5. SCADA Mimics

(a) The SCADA mimics shall be based on the P&IDs based on situational awareness or high-performance HMI standard objects.

(b) All SCADA and HMI mimics will be presented to the TNPA (as part of the control and system functional design specification (FDS), generated by the Contractor) for comments before development of the software commences.

(c) An overview mimic of the complete caisson gate shall be programmed as well as detailed mimics of each process area.

(d) A mimic shall also be provided to indicate the status of all communications networks, electrical equipment (in single line diagram format), and control network (showing PLC and other electronic equipment statuses).

(e) A navigation screen on the overview mimic shall be provided from where the operator can navigate from the overview to detailed screens for the auxiliary/common equipment and instrumentation not associated with a particular area.

(f) The mimics shall be similar to the mimics shown on the respective HMI, but be more detailed and not be a direct copy of the displays shown on the HMI at the PLC.

(g) The mimics for the SCADA and HMIs are an iterative process whereby the Engineer, Employer, and Contractor shall provide several comments before the mimics are finalised. Therefore, the Contractor shall allow for a minimum of five iterations to format and update the mimics until they meet the requirements of the Engineer and Employer.

(h) Maintenance requirements and status (includes last service/maintenance date, who performed service and details of maintenance; next service/maintenance date and warnings). All maintenance schedules from the O&M manuals will be available in electronic format on the SCADA. The SCADA and historian of the plant shall be integrated into the maintenance platform of the municipality with maintenance schedules (scheduled, preventative and reactive) being shown on the SCADA. Additionally, all maintenance logs shall be imported into this SCADA for record keeping. These logs will be developed in conjunction with the Employers maintenance departments and asset management department and will integrate with the TNPA's asset management system. Historian data shall be structured in a way for easy integration into the asset management data base in future.

2.6.6. SCADA Historian

(a) The Historian shall be an industrial historian software package based on a Microsoft SQL database technology

(b) A data warehouse specialist shall be employed to configure the historian.

(c) The historian data warehouse shall include the following processes,

  (i) Extract data from the SCADA SQL logging database,

  (ii) Staging (Cleaning data, null handling etc)

  (iii) Transform (Applying process rules to data, calculations, aggregation of data)

  (iv) Data warehouse data model configuration (Putting data into star schema, with fact tables and dimensions)

  (v) Configuration of gateway to import data cube into visualisation/reporting software.

(d) The Historian data warehouse architecture and reporting/dashboard requirements shall be defined by means of an arranged workshop between the Employer, Engineer, and the Contractor's data warehouse specialist prior to final implementation and tested thereafter as part of the SCADA Factory and Site Acceptance Test.

(e) The Historian shall be setup as to enable secure remote connection by the Employer, and Engineer as a remote network data-source that can be queried/interfaced to with one of the following industry accepted standards:

  (i) OBDC

  (ii) OLE DB

  (iii) REST API

(f) The historian software shall have a web client interface allowing for dynamic reporting and visualisation.

2.6.7. SCADA Control Dock Master's Room and Furniture

(a) The Contractor shall allow for at least two meetings between the Contractor, the SI, the Engineer, the Architect and the Client to finalise the Dock Master's Control Room layout and cable routing herein. A workstation and Control Room layout (showing all electronic equipment, power socket outlets and cable routes) shall be submitted by the Contractor for approval to the Engineer before procurement of any furniture.

(b) The SCADA furniture will be designed and supplied by a control room specialist. The layout shall be approved by the Client and Engineer.

(c) Furniture for the SCADA workstation shall include the following:

- (i) Clean aesthetic look, matching the interior design and furniture colours of the rest of the Dock Master's office.
- (ii) Durable materials (high-pressure laminate and wood veneers).
- (iii) Ergonomic designed chairs and control room desks.
- (iv) Rear access panels for desk.
- (v) PC storage under the desk, hidden away.
- (vi) UPS storage under the desk, hidden away.
- (vii) 19" rack / storage under the desk, hidden away
- (viii) Hidden cable management system.
- (ix) Back plate with cantilever arm to mount flat screens.
- (x) Power distribution system behind or below desk.

2.7. RUGGARISED TABLET

(d) One Rugged tablet for industrial application (with rubberised cover) shall be provided and will be used by the Dock master primarily for monitoring. Control shall be possible in case of emergencies.

(e) The tablet shall use a Windows based operating system that makes allowance for IIoT & Qualcomm Snapdragon processing.

(f) A mobile version of the SCADA software shall be loaded to the tablet.

(g) The Contractor shall allow for configuration and setup of the rugged tablet.

(h) The rugged tablet shall connect to the local WIFI access and not require an Internet connection to use the SCADA performance anywhere software.

2.8. TELEMETRY

The works under this section shall comply with:

Technical Data Sheet: DS-II-0004	Radio Telemetry
Engineering Specification: SPE-II-0004	Radio telemetry

2.8.1. General

(a) The communication between the caisson gate PLC and the Dock Master's office SCADA shall be established via a licence free Wireless Ethernet point-to-point link. The Wireless Ethernet shall relay information from the caisson gate to the Dock Master's office for monitoring at the remote SCADA.

(b) The Contractor shall perform a path loss study to ensure a suitable route can be established for communication to the Dock Master's office for the entire movement and relocation of the caisson gate. The results with the detailed requirements of the radios, mast and antennas shall be submitted for the Engineer's approval before any equipment is purchased or installed.

2.9. INSTRUMENTATION

The works under this section shall comply with:

Technical Data Sheet: DS-II-0007	Instrumentation
Engineering Specification: SPE-II-0007	Instrumentation

2.9.1. General

(a) The Contractor shall provide instrumentation equipment as indicated on the P&IDs and the instrumentation lists attached to the specification.

(b) All instruments shall be supplied from UPS power.

(c) Instrumentation shall be connected to the PLC as indicated on the control and instrumentation cable schedule attached to the specification.

(d) The instrumentation list shall be updated by the Contractor to reflect his offered equipment and shall be submitted to the Engineer for approval before any process instruments are purchased. Detailed Instrumentation Data Sheets shall be produced by the Contractor and used for this purpose.

(e) The Contractor shall be responsible for pricing any changes to the instrumentation and control design that are caused by his/her selection of revised processes and mechanical equipment.

(f) All instrumentation equipment shall be supplied complete with mounting material and ancillary equipment required for a complete installation.

(g) All instrumentation shall be suitable for installation under the corrosive conditions of the caisson gate.

2.9.2. Installation, Inspection and Testing

(a) Instrument transmitters shall be mounted separately from sensors in a dedicated transmitter enclosure (if outdoors) and shall allow local indication as and where specified in the Instrumentation List.

(a) All sensor mounting material and brackets shall be stainless steel 316.

(b) Instrument transmitters installed indoors shall be surface mounted. Mounting material and brackets shall be stainless steel.

(c) The outdoor transmitters with local indication shall be fitted with covers to protect the screens from solar degradation

(d) Instrumentation installed outdoors shall have their transmitters installed in a Stainless Steel 316 IP 65 weather proof powder coated enclosure near the point of measurement.

(e) All instrumentation that is not an integral part of mechanical equipment or part of a vendor package unit shall be supplied and installed by the Contractor together with all brackets, adaptors and connectors that may be necessary. The Contractor shall produce instrument hook-up drawings for approval by the Engineer prior to installation.

(f) The prices quoted for instrumentation shall include all process connections, adapters, brackets, utility junction boxes, glands, wires and labels as well as set-up and calibration of the instrumentation.

(g) The instruments shall be calibrated and calibration certificates shall be supplied and submitted to the Engineer for review as well as filed in the O&M Manuals.

3. ELECTRICAL AND ELECTRONIC SCHEDULES

The preliminary electrical and electronic schedules are included hereunder Appendix A of this project specification.

The final schedules depend on the Contractor's Design and shall be updated by the Contractor wherever applicable

4. ANNEXURE B(i)

Electrical and Electronic Schedules

a) **DB-CAISSON**

(i)	Motor and Equipment Schedules	507343_DB-CAISSON_MES
(ii)	Motor and Equipment Cable Schedules	507343_DB-CAISSON_CAB
(iii)	Instrumentation and Control Cable Schedule	507343_DB-CAISSON_I&CS
(iv)	IO List	507343_DB-CAISSON_IOList

5. PART C4 ANNEXURE B

See book of drawings for Electrical Control and Instrumentation Drawings.

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504373		Document Number	Rev	Date
Sturrock Caisson Gate		*504373_DB-Caisson_MES*	T0	12-Jun-20
DB-Caisson - Motor and Equipment Schedule				

Item No	Tag No	Description	Location	Starter	Volt	Ph	Rating	Unit	Supply Side Ratings				Typical Equipment Rating			Util. Factor	Standby Power
									S kVA	Amps	PF	Drive Eff.	Amps	PF	Eff.		
1	IN-01	DB-Caisson Incomer 1	MCC Room	INCOMER	400	3	**63**	A	29	47	0.62	-	-	-	-	-	-
2	IN-02	DB-Caisson Incomer 2	MCC Room	INCOMER	400	3	**63**	A	29	47	0.62	-	-	-	-	-	-
3	GEN-01	DB-Caisson Generator Incomer	MCC Room	INCOMER	400	3	**63**	A	29	47	0.80	-	-	-	-	-	-
4	CS-XV-01	Scuttle Tank 1 Sea Water Inlet/Outlet Modulating Control Valve 1	Dry Air Space Above Scuttle Tank 1	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
5	CS-XV-02	Scuttle Tank 1 Sea Water Inlet/Outlet Modulating Control Valve 2	Dry Air Space Above Scuttle Tank 1	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
6	CS-XV-03	Scuttle Tank 2 Sea Water Inlet/Outlet Modulating Control Valve 1	Dry Air Space Above Scuttle Tank 2	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
7	CS-XV-04	Scuttle Tank 2 Sea Water Inlet/Outlet Modulating Control Valve 2	Dry Air Space Above Scuttle Tank 2	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
8	CS-XV-05	Scuttle Tank 3 Sea Water Inlet/Outlet Modulating Control Valve 1	Dry Air Space Above Scuttle Tank 3	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
9	CS-XV-06	Scuttle Tank 3 Sea Water Inlet/Outlet Modulating Control Valve 2	Dry Air Space Above Scuttle Tank 3 A	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
10	CS-XV-07	Scuttle Tank 1 Compressed Air Inlet/Outlet Actuated Valve	Above Caisson Gate Deck	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
11	CS-XV-08	Scuttle Tank 2 Compressed Air Inlet/Outlet Actuated Valve	Above Caisson Gate Deck	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
12	CS-XV-09	Scuttle Tank 3 Compressed Air Inlet/Outlet Actuated Valve	Above Caisson Gate Deck	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
13	CS-XV-10	Air vent Actuated Valve	Above Caisson Gate Deck	FDR	400	3	1.5	kW	2.5	3.6	0.81	1	3.6	0.81	0.74	1	YES
14	CS-FN-01	Ventilation Fan 1	Above Caisson Gate Deck	FDR	400	3	0.1	kW	0.2	0.3	0.7	1	0.3	0.7	0.6	1	YES
15	CS-FN-02	Ventilation Fan 2	Above Caisson Gate Deck	FDR	400	3	0.1	kW	0.2	0.3	0.7	1	0.3	0.7	0.6	1	YES
16	CS-FN-03	Ventilation Fan 3	Above Caisson Gate Deck	FDR	400	3	0.1	kW	0.2	0.3	0.7	1	0.3	0.7	0.6	1	YES
17	CS-FN-04	Ventilation Fan 4	Above Caisson Gate Deck	FDR	400	3	0.1	kW	0.2	0.3	0.7	1	0.3	0.7	0.6	1	YES
18	CS-FN-05	Ventilation Fan 5	Above Caisson Gate Deck	FDR	400	3	0.1	kW	0.2	0.3	0.7	1	0.3	0.7	0.6	1	YES
19	CS-FN-06	Ventilation Fan 6	Above Caisson Gate Deck	FDR	400	3	0.1	kW	0.2	0.3	0.7	1	0.3	0.7	0.6	1	YES
20	CS-FN-07	Ventilation Fan 7	Above Caisson Gate Deck	FDR	400	3	0.1	kW	0.2	0.3	0.7	1	0.3	0.7	0.6	1	YES
21	CS-FN-08	Ventilation Fan 8	Above Caisson Gate Deck	FDR	400	3	0.1	kW	0.2	0.3	0.7	1	0.3	0.7	0.6	1	YES
22	CS-L-01	Light Circuit A1	Dry Air Spaces	FDR	400	3	0.3	kW	0.7	1.0	0.7	1	1.0	0.7	0.62	0	YES
23	CS-L-02	Light Circuit A2	Dry Air Spaces	FDR	400	3	0.3	kW	0.7	1.0	0.7	1	1.0	0.7	0.62	0	YES
24	CS-L-03	Light Circuit A3	Dry Air Spaces	FDR	400	3	0.3	kW	0.7	1.0	0.7	1	1.0	0.7	0.62	0	YES
25	CS-L-04	Light Circuit B1	Dry Air Spaces	FDR	400	3	0.3	kW	0.7	1.0	0.7	1	1.0	0.7	0.62	0	YES
26	CS-L-05	Light Circuit B2	Dry Air Spaces	FDR	400	3	0.3	kW	0.7	1.0	0.7	1	1.0	0.7	0.62	0	YES
27	CS-L-06	Light Circuit B3	Dry Air Spaces	FDR	400	3	0.3	kW	0.7	1.0	0.7	1	1.0	0.7	0.62	0	YES
28	CS-L-07	Light Circuit End 1	Dry Air Spaces	FDR	400	3	0.3	kW	0.7	1.0	0.7	1	1.0	0.7	0.62	0	YES
29	CS-L-08	Light Circuit End 2	Dry Air Spaces	FDR	400	3	0.3	kW	0.7	1.0	0.7	1	1.0	0.7	0.62	0	YES
30	CS-L-09	Light Circuit End 3	Dry Air Spaces	FDR	400	3	0.3	kW	0.7	1.0	0.7	1	1.0	0.7	0.62	0	YES
31	CS-P-01	Single Phase Socket Outlets Circuit	Dry Air Spaces	FDR	230	1	1	kW	1.0	4.3	0.79	1	4.3	0.79	0.74	0	YES
32	CS-P-02	Single Phase Socket Outlets Circuit	Dry Air Spaces	FDR	230	1	1	kW	1.0	4.3	0.79	1	4.3	0.79	0.74	0	YES
33	CS-PP-01	Three Phase Socket Outlets Circuit	Dry Air Spaces	FDR	400	3	5	kW	7.9	11.4	0.81	1	11.4	0.81	0.78	0	YES
34	CS-PP-02	Three Phase Socket Outlets Circuit	Dry Air Spaces	FDR	400	3	5	kW	7.9	11.4	0.81	1	11.4	0.81	0.78	0	YES
35	CS-PP-03	Three Phase Socket Outlets Circuit	Dry Air Spaces	FDR	400	3	5	kW	7.9	11.4	0.81	1	11.4	0.81	0.78	0	YES
36	CS-PP-04	Three Phase Socket Outlets Circuit	Dry Air Spaces	FDR	400	3	5	kW	7.9	11.4	0.81	1	11.4	0.81	0.78	0	YES
37	CS-PP-05	Three Phase Socket Outlets Circuit	Side of DB-Caisson	FDR	400	3	5	kW	7.9	11.4	0.81	1	11.4	0.81	0.78	0	YES
38	LCC-CAISSON	Control Console	Above Caisson Gate Deck	FDR	230	1	1	kW	1.0	4.3	0.79	1	4.3	0.79	0.74	1	YES
39	CS-YT-01	Fire Detection Control Panel	Above Caisson Gate Deck	FDR	230	1	1	kW	1.0	4.3	0.79	1	4.3	0.79	0.74	1	YES

504373
Sturrock Caisson Gate
DB-Caisson - Cable Schedule

Document Number	Rev	Date
504373_DB-Caisson_CAB	T0	12-Jun-20

Parameters		Defaults	Assumptions	
Fault Level	**5**	*kA*		
Voltage	400	400	Maximum sustained conductor temperature	70˚C
Ambient Temperature	30	30	Short Circuit max conductor temp is 160˚C for 1 sec	
Conductor Operating Temperature	70	70	Powerfactor	1
Ground Temperature	25	25	Balanced Phases	
Ground Thermal Resistivity	1.2	1.2	Multicore PVC Cu Insulated Cables	
Depth of laying to top of cable	0.6	0.5	Assumed Frequencies	49-61HZ
Method of installation in ground	pipes	ground/ pipes	Resistivity of conductor material at average temp during SC ($\Omega.mm^2/m$)	0.023
At coast or highveld	Coastal	Coastal/ Highveld	for further assumptions refer to SANS 10142-1	

	Cable Route															Circuit Breaker		Earth		
	From		To				Cores													
Item No	Equipment Tag No.	Description	Equipment Tag No	Description	Circuit Type	Estimate Length	Cores per cable	# of cores per phase	Armouring	Load Current (A)	Installation method	Allowable Volt Drop	Derating factor	Actual Volt Drop	Cable Type	Estimated Circuit breaker	Ii (A)	ECC BCEC (mm^2)	Lmax (ECC)	Field Control
1	EK-01	Existing Electrical Kiosk	IN-01	DB-Caisson Incomer 1	INCOMER	70	4	1	Flexible Cu PVC Nitrile Trailing	47	meth_4or6	3.0%	0.85	2.64%	1 x 4C x16mm^2	63	126	16	883	
2	EK-02	Existing Electrical Kiosk	IN-02	DB-Caisson Incomer 2	INCOMER	70	4	1	Flexible Cu PVC Nitrile Trailing	47	meth_4or6	3.0%	0.85	2.64%	1 x 4C x16mm^2	63	126	16	883	
3	GEN-01	Portable Generator	GEN-01	DB-Caisson Generator Incomer	INCOMER	20	4	1	SWA	47	meth_4or6	3.0%	0.85	0.75%	1 x 4C x16mm^2	63	126	16	883	
4	DB-Caisson	DB	CS-XV-01	Scuttle Tank 1 Sea Water Inlet/Outlet Modulating Control Valve 1	FDR	50	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.69%	1 x 4C x2,5mm^2	10	120	2.5	145	
5	DB-Caisson	DB	CS-XV-02	Scuttle Tank 1 Sea Water Inlet/Outlet Modulating Control Valve 2	FDR	50	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.69%	1 x 4C x2,5mm^2	10	120	2.5	145	
6	DB-Caisson	DB	CS-XV-03	Scuttle Tank 2 Sea Water Inlet/Outlet Modulating Control Valve 1	FDR	50	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.69%	1 x 4C x2,5mm^2	10	120	2.5	145	
7	DB-Caisson	DB	CS-XV-04	Scuttle Tank 2 Sea Water Inlet/Outlet Modulating Control Valve 2	FDR	50	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.69%	1 x 4C x2,5mm^2	10	120	2.5	145	
8	DB-Caisson	DB	CS-XV-05	Scuttle Tank 3 Sea Water Inlet/Outlet Modulating Control Valve 1	FDR	50	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.69%	1 x 4C x2,5mm^2	10	120	2.5	145	
9	DB-Caisson	DB	CS-XV-06	Scuttle Tank 3 Sea Water Inlet/Outlet Modulating Control Valve 2	FDR	50	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.69%	1 x 4C x2,5mm^2	10	120	2.5	145	
10	DB-Caisson	DB	CS-XV-07	Scuttle Tank 1 Compressed Air Inlet/Outlet Actuated Valve	FDR	10	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.14%	1 x 4C x2,5mm^2	10	120	2.5	145	
11	DB-Caisson	DB	CS-XV-08	Scuttle Tank 2 Compressed Air Inlet/Outlet Actuated Valve	FDR	10	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.14%	1 x 4C x2,5mm^2	10	120	2.5	145	
12	DB-Caisson	DB	CS-XV-09	Scuttle Tank 3 Compressed Air Inlet/Outlet Actuated Valve	FDR	10	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.14%	1 x 4C x2,5mm^2	10	120	2.5	145	
13	DB-Caisson	DB	CS-XV-10	Air vent Actuated Valve	FDR	10	4	1	SWA	3.6	meth_4or6	2.0%	0.87	0.14%	1 x 4C x2,5mm^2	10	120	2.5	145	
14	DB-Caisson	DB	CS-FN-01	Ventilation Fan 1	FDR	30	3	1	SWA	0.3	meth_4or6	2.0%	0.87	0.00%	1 x 3C x2.5mm^2	10	120	16	1131	
15	DB-Caisson	DB	CS-FN-02	Ventilation Fan 2	FDR	30	3	1	SWA	0.3	meth_4or6	2.0%	0.87	0.00%	1 x 3C x2.5mm^2	10	120	16	1131	
16	DB-Caisson	DB	CS-FN-03	Ventilation Fan 3	FDR	30	3	1	SWA	0.3	meth_4or6	2.0%	0.87	0.00%	1 x 3C x2.5mm^2	10	120	16	1131	
17	DB-Caisson	DB	CS-FN-04	Ventilation Fan 4	FDR	30	3	1	SWA	0.3	meth_4or6	2.0%	0.87	0.00%	1 x 3C x2.5mm^2	10	120	16	1131	
18	DB-Caisson	DB	CS-FN-05	Ventilation Fan 5	FDR	40	3	1	SWA	0.3	meth_4or6	2.0%	0.87	0.01%	1 x 3C x2.5mm^2	10	120	16	1131	
19	DB-Caisson	DB	CS-FN-06	Ventilation Fan 6	FDR	40	3	1	SWA	0.3	meth_4or6	2.0%	0.87	0.01%	1 x 3C x2.5mm^2	10	120	16	1131	
20	DB-Caisson	DB	CS-FN-07	Ventilation Fan 7	FDR	40	3	1	SWA	0.3	meth_4or6	2.0%	0.87	0.01%	1 x 3C x2.5mm^2	10	120	16	1131	
21	DB-Caisson	DB	CS-FN-08	Ventilation Fan 8	FDR	40	3	1	SWA	0.3	meth_4or6	2.0%	0.87	0.01%	1 x 3C x2.5mm^2	10	120	16	1131	
22	DB-Caisson	DB	CS-L-01	Light Circuit A1	FDR	40	3	1	SWA	1.0	meth_4or6	2.0%	0.87	0.02%	1 x 3C x2.5mm^2	10	120	16	1131	
23	DB-Caisson	DB	CS-L-02	Light Circuit A2	FDR	60	3	1	SWA	1.0	meth_4or6	2.0%	0.87	0.02%	1 x 3C x2.5mm^2	10	120	16	1131	
24	DB-Caisson	DB	CS-L-03	Light Circuit A3	FDR	80	3	1	SWA	1.0	meth_4or6	2.0%	0.87	0.03%	1 x 3C x2.5mm^2	10	120	16	1131	
25	DB-Caisson	DB	CS-L-04	Light Circuit B1	FDR	80	3	1	SWA	1.0	meth_4or6	2.0%	0.87	0.03%	1 x 3C x2.5mm^2	10	120	16	1131	
26	DB-Caisson	DB	CS-L-05	Light Circuit B2	FDR	40	3	1	SWA	1.0	meth_4or6	2.0%	0.87	0.02%	1 x 3C x2.5mm^2	10	120	16	1131	
27	DB-Caisson	DB	CS-L-06	Light Circuit B3	FDR	60	3	1	SWA	1.0	meth_4or6	2.0%	0.87	0.02%	1 x 3C x2.5mm^2	10	120	16	1131	
28	DB-Caisson	DB	CS-L-07	Light Circuit End 1	FDR	80	3	1	SWA	1.0	meth_4or6	2.0%	0.87	0.03%	1 x 3C x2.5mm^2	10	120	16	1131	
29	DB-Caisson	DB	CS-L-08	Light Circuit End 2	FDR	80	3	1	SWA	1.0	meth_4or6	2.0%	0.87	0.03%	1 x 3C x2.5mm^2	10	120	16	1131	
30	DB-Caisson	DB	CS-L-09	Light Circuit End 3	FDR	100	3	1	SWA	1.0	meth_4or6	2.0%	0.87	0.04%	1 x 3C x2.5mm^2	10	120	16	1131	

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504373
Sturrock Caisson Gate
DB-Caisson - Cable Schedule

Document Number	Rev	Date
504373_DB-Caisson_CAB	T0	12-Jun-20

Parameters		*Defaults*	Assumptions	
Fault Level	**5**	*kA*		
Voltage	400	400	Maximum sustained conductor temperature	70˚C
Ambient Temperature	30	30	Short Circuit max conductor temp is 160˚C for 1 sec	
Conductor Operating Temperature	70	70	Powerfactor	1
Ground Temperature	25	25	Balanced Phases	
Ground Thermal Resistivity	1.2	1.2	Multicore PVC Cu Insulated Cables	
Depth of laying to top of cable	0.6	0.5	Assumed Frequencies	49-61HZ
Method of installation in ground	pipes	ground/ pipes	Resistivity of conductor material at average temp during SC (Ω.mm²/m)	0.023
At coast or highveld	Coastal	Coastal/ Highveld	for further assumptions refer to SANS 10142-1	

	Cable Route																Circuit Breaker		Earth		
	From		To					Cores													
Item No	Equipment Tag No.	Description	Equipment Tag No	Description	Circuit Type	Estimate Length	Cores per cable	# of cores per phase	Armouring	Load Current (A)	Installation method	Allowable Volt Drop	Derating factor	Actual Volt Drop	Cable Type	Estimated Circuit breaker	Ii (A)	ECC BCEC (mm²)	Lmax (ECC)	Field Control
31	DB-Caisson	DB	CS-P-01	Single Phase Socket Outlets Circuit	FDR	60	3	1	SWA	4.3	meth_4or6	2.0%	0.87	0.10%	1 x 3C x2.5mm²	20	240	16	566	
32	DB-Caisson	DB	CS-P-02	Single Phase Socket Outlets Circuit	FDR	60	3	1	SWA	4.3	meth_4or6	2.0%	0.87	0.10%	1 x 3C x2.5mm²	20	240	16	566	
33	DB-Caisson	DB	CS-PP-01	Three Phase Socket Outlets Circuit	FDR	60	4	1	SWA	11.4	meth_4or6	2.0%	0.87	1.64%	1 x 4C x6mm²	32	384	4	72	
34	DB-Caisson	DB	CS-PP-02	Three Phase Socket Outlets Circuit	FDR	60	4	1	SWA	11.4	meth_4or6	2.0%	0.87	1.64%	1 x 4C x6mm²	32	384	4	72	
35	DB-Caisson	DB	CS-PP-03	Three Phase Socket Outlets Circuit	FDR	60	4	1	SWA	11.4	meth_4or6	2.0%	0.87	1.64%	1 x 4C x6mm²	32	384	4	72	
36	DB-Caisson	DB	CS-PP-04	Three Phase Socket Outlets Circuit	FDR	60	4	1	SWA	11.4	meth_4or6	2.0%	0.87	1.64%	1 x 4C x6mm²	32	384	4	72	
37	DB-Caisson	DB	CS-PP-05	Three Phase Socket Outlets Circuit	FDR	60	4	1	SWA	11.4	meth_4or6	2.0%	0.87	1.64%	1 x 4C x6mm²	32	384	4	72	
38	DB-Caisson	DB	LCC-CAISSON	Control Console	FDR	2	3	1	SWA	4.3	meth_4or6	2.0%	0.87	0.00%	1 x 3C x2.5mm²	10	120	16	1131	
39	DB-Caisson	DB	CS-YT-01	Fire Detection Control Panel	FDR	10	3	1	SWA	4.3	meth_4or6	2.0%	0.87	0.02%	1 x 3C x2.5mm²	10	120	16	1131	

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504373 *Sturrock Caisson Gate* **LCC-Caisson - Instrumentation and Control Cable Schedule**	Document Number *504373_DB-Caisson_I&CS*	Rev T0	Date 12-Jun-20

Item No	From		To		Estimate Length	Signal		Power Cables		Fieldbus Cable	Control Cables			Instrumentation Cables			Function
	Tag No.	Description	Tag No.	Description		Analog	Digital	Cores	Size mm²	Protocol	No.	Cores	Size mm²	No.	Pairs/ Triads	Size mm²	
-																	
1	DB-Caisson	DB	IN-01	DB-Caisson Incomer 1	70												Not Required
2	DB-Caisson	DB	IN-02	DB-Caisson Incomer 2	70												Not Required
3	DB-Caisson	DB	GEN-01	DB-Caisson Generator Incomer	20												Not Required
4	DB-Caisson	DB	CS-XV-01	Scuttle Tank 1 Sea Water Inlet/Outlet Modulating Control Valve 1	50	x					1	7C	2.5				Open/Stop/Close Cmnd
5	DB-Caisson	DB	CS-XV-02	Scuttle Tank 1 Sea Water Inlet/Outlet Modulating Control Valve 2	50	x					1	7C	2.5				Open/Stop/Close Cmnd
6	DB-Caisson	DB	CS-XV-03	Scuttle Tank 2 Sea Water Inlet/Outlet Modulating Control Valve 1	50	x					1	7C	2.5				Open/Stop/Close Cmnd
7	DB-Caisson	DB	CS-XV-04	Scuttle Tank 2 Sea Water Inlet/Outlet Modulating Control Valve 2	50	x					1	7C	2.5				Open/Stop/Close Cmnd
8	DB-Caisson	DB	CS-XV-05	Scuttle Tank 3 Sea Water Inlet/Outlet Modulating Control Valve 1	50	x					1	7C	2.5				Open/Stop/Close Cmnd
9	DB-Caisson	DB	CS-XV-06	Scuttle Tank 3 Sea Water Inlet/Outlet Modulating Control Valve 2	50	x					1	7C	2.5				Open/Stop/Close Cmnd
10	DB-Caisson	DB	CS-XV-07	Scuttle Tank 1 Compressed Air Inlet/Outlet Actuated Valve	10		x				1	7C	2.5				Open/Close Cmnd
11	DB-Caisson	DB	CS-XV-08	Scuttle Tank 2 Compressed Air Inlet/Outlet Actuated Valve	10		x				1	7C	2.5				Open/Close Cmnd
12	DB-Caisson	DB	CS-XV-09	Scuttle Tank 3 Compressed Air Inlet/Outlet Actuated Valve	10		x				1	7C	2.5				Open/Close Cmnd
13	DB-Caisson	DB	CS-XV-10	Air vent Actuated Valve	10		x				1	7C	2.5				Open/Close Cmnd
14	DB-Caisson	DB	CS-FN-01	Ventilation Fan 1	30		x				1	7C	2.5				On/Off
15	DB-Caisson	DB	CS-FN-02	Ventilation Fan 2	30		x				1	7C	2.5				On/Off
16	DB-Caisson	DB	CS-FN-03	Ventilation Fan 3	30		x				1	7C	2.5				On/Off
17	DB-Caisson	DB	CS-FN-04	Ventilation Fan 4	30		x				1	7C	2.5				On/Off
18	DB-Caisson	DB	CS-FN-05	Ventilation Fan 5	40		x				1	7C	2.5				On/Off
19	DB-Caisson	DB	CS-FN-06	Ventilation Fan 6	40		x				1	7C	2.5				On/Off
20	DB-Caisson	DB	CS-FN-07	Ventilation Fan 7	40		x				1	7C	2.5				On/Off
21	DB-Caisson	DB	CS-FN-08	Ventilation Fan 8	40		x				1	7C	2.5				On/Off
22	DB-Caisson	DB	CS-L-01	Light Circuit A1	40												Not Required
23	DB-Caisson	DB	CS-L-02	Light Circuit A2	60												Not Required
24	DB-Caisson	DB	CS-L-03	Light Circuit A3	80												Not Required
25	DB-Caisson	DB	CS-L-04	Light Circuit B1	80												Not Required
26	DB-Caisson	DB	CS-L-05	Light Circuit B2	40												Not Required
27	DB-Caisson	DB	CS-L-06	Light Circuit B3	60												Not Required
28	DB-Caisson	DB	CS-L-07	Light Circuit End 1	80												Not Required
29	DB-Caisson	DB	CS-L-08	Light Circuit End 2	80												Not Required
30	DB-Caisson	DB	CS-L-09	Light Circuit End 3	100												Not Required
31	DB-Caisson	DB	CS-P-01	Single Phase Socket Outlets Circuit	60												Not Required
32	DB-Caisson	DB	CS-P-02	Single Phase Socket Outlets Circuit	60												Not Required
33	DB-Caisson	DB	CS-PP-01	Three Phase Socket Outlets Circuit	60												Not Required
34	DB-Caisson	DB	CS-PP-02	Three Phase Socket Outlets Circuit	60												Not Required
35	DB-Caisson	DB	CS-PP-03	Three Phase Socket Outlets Circuit	60												Not Required
36	DB-Caisson	DB	CS-PP-04	Three Phase Socket Outlets Circuit	60												Not Required
37	DB-Caisson	DB	CS-PP-05	Three Phase Socket Outlets Circuit	60												Not Required
38	DB-Caisson	DB	LCC-CAISSON	Control Console	2												Not Required
39	DB-Caisson	DB	CS-YT-01	Fire Detection Control Panel	10					EtherNetIP							
40	LCC-Caisson	Control Console	CS-LT-01	Scuttle Tank 1 Water Level Transmitter	100	x		3C	2.5					1	1Pair	1.5	Level Measurement
41	LCC-Caisson	Control Console	CS-LS-01	Scuttle Tank 1 Level Float Switch	100		x							1	1Pair	1.5	Level Switch
42	LCC-Caisson	Control Console	CS-PT-01	Scuttle Tank 1 Air Pressure Transmitter	10	x		3C	2.5					1	1Pair	1.5	Air Pressure Measurement

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504373 *Sturrock Caisson Gate* **LCC-Caisson - Instrumentation and Control Cable Schedule**	Document Number *504373_DB-Caisson_I&CS*	Rev T0	Date 12-Jun-20

Item No	From		To		Estimate Length	Signal		Power Cables		Fieldbus Cable	Control Cables			Instrumentation Cables			Function
	Tag No.	Description	Tag No.	Description		Analog	Digital	Cores	Size mm²	Protocol	No.	Cores	Size mm²	No.	Pairs/ Triads	Size mm²	
43	LCC-Caisson	Control Console	CS-LT-02	Scuttle Tank 2 Water Level Transmitter	100	x		3C	2.5					1	1Pair	1.5	Level Measurement
44	LCC-Caisson	Control Console	CS-LS-02	Scuttle Tank 2 Level Float Switch	100		x							1	1Pair	1.5	Level Switch
45	LCC-Caisson	Control Console	CS-PT-02	Scuttle Tank 2 Air Pressure Transmitter	10	x		3C	2.5					1	1Pair	1.5	Air Pressure Measurement
46	LCC-Caisson	Control Console	CS-LT-03	Scuttle Tank 3 Water Level Transmitter	100	x		3C	2.5					1	1Pair	1.5	Level Measurement
47	LCC-Caisson	Control Console	CS-LS-03	Scuttle Tank 3 Level Float Switch	100		x							1	1Pair	1.5	Level Switch
48	LCC-Caisson	Control Console	CS-PT-03	Scuttle Tank 3 Air Pressure Transmitter	10	x		3C	2.5					1	1Pair	1.5	Air Pressure Measurement
49	LCC-Caisson	Control Console	CS-AT-01	Oxygen Meter 1	80	x		3C	2.5					1	1Pair	1.5	Oxygen Measurement
50	LCC-Caisson	Control Console	CS-AT-02	Oxygen Meter 2	80	x		3C	2.5					1	1Pair	1.5	Oxygen Measurement
51	LCC-Caisson	Control Console	CS-AT-03	Oxygen Meter 3	80	x		3C	2.5					1	1Pair	1.5	Oxygen Measurement
52	LCC-Caisson	Control Console	CS-AT-04	Oxygen Meter 4	80	x		3C	2.5					1	1Pair	1.5	Oxygen Measurement
53	LCC-Caisson	Control Console	CS-AT-05	Oxygen Meter 5	80	x		3C	2.5					1	1Pair	1.5	Oxygen Measurement
54	LCC-Caisson	Control Console	CS-AT-06	Oxygen Meter 6	80	x		3C	2.5					1	1Pair	1.5	Oxygen Measurement
55	LCC-Caisson	Control Console	CS-AT-07	Oxygen Meter 7	80	x		3C	2.5					1	1Pair	1.5	Oxygen Measurement
56	LCC-Caisson	Control Console	CS-AT-08	Oxygen Meter 8	80	x		3C	2.5					1	1Pair	1.5	Oxygen Measurement
57	LCC-Caisson	Control Console	CS-PT-04	Main Incoming Compressed Air Pressure Transmitter	10	x								1	1Pair	1.5	Air Pressure Measurement
58	LCC-Caisson	Control Console	CS-PT-05	Main Incoming Compressed Air Pressure Transmitter	10	x								1	1Pair	1.5	Air Pressure Measurement
59	LCC-Caisson	Control Console	CS-LS-04	Scuttle Tank 1 Sea Water Valve 1 Sump Water Level Float Switch	60		x							1	1Pair	1.5	Water Level / Leak
60	LCC-Caisson	Control Console	CS-LS-05	Scuttle Tank 1 Sea Water Valve 2 Sump Water Level Float Switch	60		x							1	1Pair	1.5	Water Level / Leak
61	LCC-Caisson	Control Console	CS-LS-06	Scuttle Tank 2 Sea Water Valve 1 Sump Water Level Float Switch	60		x							1	1Pair	1.5	Water Level / Leak
62	LCC-Caisson	Control Console	CS-LS-07	Scuttle Tank 2 Sea Water Valve 2 Sump Water Level Float Switch	60		x							1	1Pair	1.5	Water Level / Leak
63	LCC-Caisson	Control Console	CS-LS-08	Scuttle Tank 3 Sea Water Valve 1 Sump Water Level Float Switch	60		x							1	1Pair	1.5	Water Level / Leak
64	LCC-Caisson	Control Console	CS-LS-09	Scuttle Tank 3 Sea Water Valve 2 Sump Water Level Float Switch	60		x							1	1Pair	1.5	Water Level / Leak

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504373 *Sturrock Caisson Gate* **LCC-Caisson - I/O List**	Document Number *504373_DB-Caisson_IOList*	Rev T0	Date 12-Jun-20

Item No	Tag No	Description		Digital Input										Digital Output			Analog Input				Analog Ouput		Remarks
			Comms	CB Tripped	Fault	E-Stop	Running/ Stopped	Opened/Closed	Closed	Auto/Man/Off	Overheat	Seal Failure	Other	Start/Stop	Open/Close	Other	Measured Value	Amps	Volt	kW	Set Point	Other	
1	xxx-AL-01	Alarm											1										DI Alarm Accept, DO Alarm
2	xxx-UPS-01	UPS											2										on,standby, charging,fault
3	IN-01	DB-Caisson Incomer 1																					
4	IN-02	DB-Caisson Incomer 2																					
5	GEN-01	DB-Caisson Generator Incomer																					
6	CS-XV-01	Scuttle Tank 1 Sea Water Inlet/Outlet Modulating Control Valve 1						1							1								
7	CS-XV-02	Scuttle Tank 1 Sea Water Inlet/Outlet Modulating Control Valve 2						1							1								
8	CS-XV-03	Scuttle Tank 2 Sea Water Inlet/Outlet Modulating Control Valve 1						1							1								
9	CS-XV-04	Scuttle Tank 2 Sea Water Inlet/Outlet Modulating Control Valve 2						1							1								
10	CS-XV-05	Scuttle Tank 3 Sea Water Inlet/Outlet Modulating Control Valve 1						1							1								
11	CS-XV-06	Scuttle Tank 3 Sea Water Inlet/Outlet Modulating Control Valve 2						1							1								
12	CS-XV-07	Scuttle Tank 1 Compressed Air Inlet/Outlet Actuated Valve						1							1								
13	CS-XV-08	Scuttle Tank 2 Compressed Air Inlet/Outlet Actuated Valve						1							1								
14	CS-XV-09	Scuttle Tank 3 Compressed Air Inlet/Outlet Actuated Valve						1							1								
15	CS-XV-10	Air vent Actuated Valve						1							1								
16	CS-FN-01	Ventilation Fan 1					1								1								
17	CS-FN-02	Ventilation Fan 2					1								1								
18	CS-FN-03	Ventilation Fan 3					1								1								
19	CS-FN-04	Ventilation Fan 4					1								1								
20	CS-FN-05	Ventilation Fan 5					1								1								
21	CS-FN-06	Ventilation Fan 6					1								1								
22	CS-FN-07	Ventilation Fan 7					1								1								
23	CS-FN-08	Ventilation Fan 8					1								1								
24	CS-L-01	Light Circuit A1																					
25	CS-L-02	Light Circuit A2																					
26	CS-L-03	Light Circuit A3																					
27	CS-L-04	Light Circuit B1																					
28	CS-L-05	Light Circuit B2																					
29	CS-L-06	Light Circuit B3																					
30	CS-L-07	Light Circuit End 1																					
31	CS-L-08	Light Circuit End 2																					
32	CS-L-09	Light Circuit End 3																					
33	CS-P-01	Single Phase Socket Outlets Circuit																					
34	CS-P-02	Single Phase Socket Outlets Circuit																					
35	CS-PP-01	Three Phase Socket Outlets Circuit																					
36	CS-PP-02	Three Phase Socket Outlets Circuit																					
37	CS-PP-03	Three Phase Socket Outlets Circuit																					
38	CS-PP-04	Three Phase Socket Outlets Circuit																					
39	CS-PP-05	Three Phase Socket Outlets Circuit																					
40	LCC-CAISSON	Control Console																					
41	CS-YT-01	Fire Detection Control Panel	x																				
42	CS-LT-01	Scuttle Tank 1 Water Level Transmitter															1						
43	CS-LS-01	Scuttle Tank 1 Level Float Switch											1										
44	CS-PT-01	Scuttle Tank 1 Air Pressure Transmitter															1						
45	CS-LT-02	Scuttle Tank 2 Water Level Transmitter															1						

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504373 *Sturrock Caisson Gate* **LCC-Caisson - I/O List**	Document Number *504373_DB-Caisson_IOList*	Rev T0	Date 12-Jun-20

Item No	Tag No	Description		Digital Input										Digital Output			Analog Input				Analog Ouput		Remarks
			Comms	CB Tripped	Fault	E-Stop	Running/ Stopped	Opened/Closed	Closed	Auto/Man/Off	Overheat	Seal Failure	Other	Start/Stop	Open/Close	Other	Measured Value	Amps	Volt	kW	Set Point	Other	
46	CS-LS-02	Scuttle Tank 2 Level Float Switch											1										
47	CS-PT-02	Scuttle Tank 2 Air Pressure Transmitter															1						
48	CS-LT-03	Scuttle Tank 3 Water Level Transmitter															1						
49	CS-LS-03	Scuttle Tank 3 Level Float Switch											1										
50	CS-PT-03	Scuttle Tank 3 Air Pressure Transmitter															1						
51	CS-AT-01	Oxygen Meter 1															1						
52	CS-AT-02	Oxygen Meter 2															1						
53	CS-AT-03	Oxygen Meter 3															1						
54	CS-AT-04	Oxygen Meter 4															1						
55	CS-AT-05	Oxygen Meter 5															1						
56	CS-AT-06	Oxygen Meter 6															1						
57	CS-AT-07	Oxygen Meter 7															1						
58	CS-AT-08	Oxygen Meter 8															1						
59	CS-PT-04	Main Incoming Compressed Air Pressure Transmitter															1						
60	CS-PT-05	Main Incoming Compressed Air Pressure Transmitter															1						
61	CS-LS-04	Scuttle Tank 1 Sea Water Valve 1 Sump Water Level Float Switch											1										
62	CS-LS-05	Scuttle Tank 1 Sea Water Valve 2 Sump Water Level Float Switch											1										
63	CS-LS-06	Scuttle Tank 2 Sea Water Valve 1 Sump Water Level Float Switch											1										
64	CS-LS-07	Scuttle Tank 2 Sea Water Valve 2 Sump Water Level Float Switch											1										
65	CS-LS-08	Scuttle Tank 3 Sea Water Valve 1 Sump Water Level Float Switch											1										
66	CS-LS-09	Scuttle Tank 3 Sea Water Valve 2 Sump Water Level Float Switch											1										
		TOTALS		**30**										**18**			**16**				**0**		

DATA SHEET No. DS-EE-0010A
DISTRIBUTION BOARD

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**OPERATING ENVIRONMENT**			
1.1	Inland / Coastal		Coastal	
1.2	Indoor / Outdoor		Outdoor	
1.3	Site Conditions - Altitude	*m*	As per Specification	
1.4	Site Conditions - Min. / Max Ambient Temp.	*˚C / ˚C*	As per Specification	
1.5	Site Conditions - Max. Relative Humidity	*%*	As per Specification	
2	**ELECTRICAL CHARACTERISTICS**			
2.1	Supply Voltage	*V*	400	
2.2	Frequency	*Hz*	50	
2.3	DB Main Busbar Rating	*A*	As per SLD	
2.4	Fault Level Rating	*kA*	As per SLD	
2.5	Number of Phases	*Num*	3	
2.6	Cascading Allowed	*Yes / No*	No	
2.7	Control Voltage	*V*	230	
2.8	Supplied From		Various	
2.9	Upstream Supply size	*A*	63	
2.10	Earthing	*Earth Bar / Earth Stud*	Earth Bar	
2.11	Neutral	*Full / Half*	Full Neutral	
3	**CONSTRUCTION REQUIREMENTS**			
3.1	Steel Work Manufacturer			
3.2	Form of Internal Separation		2a	
3.3	Material of Construction	2.00 Mild Steel/ Electro Galvanized/ Stainless Steel/ 3CR12	Stainless Steel 316	
3.4	Ingress Protection (doors closed)	*IP*	65	
3.5	Method of Installation		Floor Standing	
3.6	Colour of Assembly		Electric Orange	
3.7	Spare Space Required	*%*	>=20	
3.8	Cable Entry	*Top / Bottom*	Bottom	
4	**DISTRIBUTION BOARDS**			
4.1	Manufacturer			
4.2	Type			
4.3	Details		As per SLD	
4.4	SABS approved	*Yes/No*	Yes	
5	**COMPONENTS**			
5.1	**Busbars**			
5.1.1	Material		Copper	
5.1.2	Tinned	*Yes / No*	Yes	
5.1.3	Current Density	*A/mm²*	<2	
5.2	**Moulded Case Circuit Breakers**			
5.2.1	Manufacturer			

DATA SHEET No. DS-EE-0010A
DISTRIBUTION BOARD

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
5.2.2	Type		Fixed	
5.2.3	Model			
5.2.4	Rated Current	*A*	As per SLD	
5.2.5	Service short-circuit breaking capacity (Ics)	*kA*		
5.2.6	Overload release		Thermal/ electronic	
5.2.7	Short-circuit release		Magnetic/ electronic	
5.3	**Miniature Circuit Breakers**			
5.3.1	Manufacturer			
5.3.2	Type			
5.3.3	Model			
5.3.4	Rated Current	*A*		
5.3.5	Service short-circuit breaking capacity (Ics)	*kA*		
5.3.6	Tripping Curve		C or as per SLD	
5.4	**Fuse-Switch-Disconnector**			
5.4.1	Manufacturer			N/A
5.4.2	Model			N/A
5.5	**Contactors**			
5.5.1	Manufacturer			
5.5.2	Model			
5.5.3	Contactor rating		AC1	
5.5.4	Coordination			
6	**SUPPLEMENTARY DETAILS**			
6.1	Witnessed factory acceptance test	*Yes/No*	Yes	
6.2	Location of FAT			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified

Name (Print): ______________________________ Signature: ________________________.

DATA SHEET No. DS-EE-0010B
GENERATOR CONNECTION BOX

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**OPERATING ENVIRONMENT**			
1.1	Inland / Coastal		Coastal	
1.2	Indoor / Outdoor		Outdoor	
1.3	Site Conditions - Altitude	*m*	As per Specification	
1.4	Site Conditions - Min. / Max Ambient Temp.	*˚C / ˚C*	As per Specification	
1.5	Site Conditions - Max. Relative Humidity	*%*	As per Specification	
2	**CONSTRUCTION REQUIREMENTS**			
2.1	Steel Work Manufacturer			
2.2	Form of Internal Separation		1	
2.3	Material of Construction	2.00 Mild Steel/ Electro Galvanized/ Stainless Steel/ 3CR12	Stainless Steel 316	
2.4	Ingress Protection (doors closed)	*IP*	65	
2.5	Method of Installation		Pedastal Mounted	
2.6	Colour of Assembly		Electric Orange	
2.7	Cable Entry	*Top / Bottom*	Bottom	
3	**3 Phase Industrial Switched Socket Outlets**			
3.1	Manufacturer			
3.2	Type			
3.3	Ingress Protection	*IP*	66 as per specifications	
3.4	Mounting	*Flush/recessed in power skirting*	Mounted inside the Generator connection box	
3.5	SABS approved	*Yes / No*	Yes	

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified

Name (Print): ______________________________ Signature: _________________________.

DATA SHEET No. DS-EE-0011
LV CABLES

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**LOW VOLTAGE CABLES**			
1.1	**DB INCOMER CABLES**			
1.1.1	Manufacturer			
1.1.2	Operating Voltage	*V*	600/1000	
1.1.3	Number of Cores	*No*	See Specifications and SLDs	
1.1.4	Size	*mm^2*		
1.1.5	Conductor Type	*Cu/Al*		
1.1.6	Cable Type			
1.1.7	Full Load Current	*A*		
1.1.8	Armouring	*Yes/No*		
1.1.9	Depth of installation	*mm (to cable centre)*		
1.1.10	Outdoor Cable Markers	*Yes/No*	No	
1.2	**FEEDER CABLES**			
1.2.1	Manufacturer			
1.2.2	Operating Voltage	*V*	600/1000	
1.2.3	Number of Cores	*No*	See Specifications and SLDs for others	
1.2.4	Size	*mm^2*		
1.2.5	Conductor Type	*Cu/Al*		
1.2.6	Cable Type			
1.2.7	Full Load Current	*A*		
1.2.8	Armouring	*Yes/No*	Yes, SWA or AWA for single core	
1.2.9	Depth of installation	*mm (to cable centre)*		
1.2.10	Outdoor Cable Markers	*Yes/No*	No	
2	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified

Name (Print): ______________________________Signature: ________________________.

DATA SHEET No. DS-EE-0012
CABLE SUPPORTS

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**CABLE LADDER**			
1.1	Manufacturer			
1.2	Type			
1.3	Material		Stainless Steel 316	
1.4	Duty	Heavy / Medium	Heavy	
1.5	Application			
2	**WIRE MESH TRAY**			
2.1	Manufacturer			
2.2	Type			
2.3	Material		Stainless Steel 316	
2.4	Duty	Heavy / Medium	Heavy	
2.5	Application			
3	**CONDUITS**			
3.1	Manufacturer			
3.2	Type			
3.3	Material		Stainless Steel 316	
3.4	Duty	Heavy / Medium	Medium	
3.5	Application		C&I cabling	
4	**UNISTRUT**			
4.1	Manufacturer			
4.2	Type			
4.3	Material		Stainless Steel 316	
4.4	Duty	Heavy / Medium	Medium	
4.5	Application		EC&I cabling	
5	**CABLE SEALING SOLUTION**			
5.1	Manufacturer			
5.2	Type			
5.3	Material			
5.4	Duty	Heavy / Medium	Medium	
5.5	Application		EC&I cabling	
6	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified

Name (Print): ______________________________ Signature: ________________________.

DATA SHEET No. DS-EE-0013
SMALL POWER

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**POWER OUTLETS**			
1.1	**Normal Switched Socket Outlets**			
1.1.1	Manufacturer			
1.1.2	Type			
1.1.3	Ingress Protection	*IP*	66 as per specifications	
1.1.4	Faceplate Colour		White	
1.1.5	Mounting	*Flush/recessed in power skirting*	Surface mounted	
1.1.6	SABS approved	*Yes / No*	Yes	
1.3	**3 Phase Industrial Switched Socket Outlets**			
1.3.1	Manufacturer			
1.3.2	Type			
1.3.3	Ingress Protection	*IP*	66 as per specifications	
1.3.4	Mounting	*Flush/recessed in power skirting*	Surface mounted	
1.3.5	SABS approved	*Yes / No*	Yes	
2	**Switch Disconnectors**			
2.1	**Double Pole**			
2.1.1	Manufacturer			
2.1.2	Type			
2.1.3	Ingress Protection	*IP*	66	
2.1.4	Mounting		Surface mounted	
2.1.5	SABS approved	*Yes / No*	Yes	
3	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified requirements

Name (Print): ______________________________***Signature:*** ________________________.

DATA SHEET No. DS-EE-0014A
LIGHTING

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**LIGHTING ACCESSORIES**			
1.1	***Lighting Ballast***			
1.1.1	Manufacturer			
1.1.2	Type			
1.1.3	Details			
1.1.4	SABS approved	*Yes/No*	Yes	
1.2	***Light Switches***			
1.2.1	Colour		White	
1.2.2	Flush mounted	*Yes/No*	No	
1.2.3	Manufacturer			
1.2.4	Type			
1.2.5	Ingress Protection		66 as per specifications	
2	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified requirements

Name (Print): ____________________________ ***Signature:*** ________________________ .

DATA SHEET No. DS-EE-0014B
LUMINAIRE SCHEDULE

Luminaire / Device Type:	Image:	Description	Ingress Protection	Supplier / Manufacturer:	Product Name / Code:	Lamp Type:	Mounting Method	OFFERED
A	 Corrosion Resistant	LED Tube vapourproof fitting with corrosion protection	IP66	BEKA Schréder, similar or equivalent	LED VLN	41W/65	Various, as per drawings	
B	 Corrosion Resistant	LED Floodlight	IP66	BEKA Schréder, similar or equivalent	LEDLUME MIDI	19W	Side of structure	

DATA SHEET No. DS-EE-0026
ELECTRICAL ACTUATORS

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**GENERAL**			
1.1	Make			
1.2	Model			
1.3	Type			
1.4	Design Life (according to SANS 60034-1)	*Class*		
1.5	Weight - Actuator	*kg*		
2	**CONTROL**			
	Remote Signals Required			
2.1	Valve Fully Open	*Yes / No*	Yes	
2.2	Valve Fully Closed	*Yes / No*	Yes	
2.3	Valve in an Intermediate Position	*Yes / No*	Yes	
2.4	Locked Out (by Switch-Disconnector)	*Yes / No*		
2.5	Local/Off/Remote	*Yes / No*	Yes	
2.6	Fault	*Yes / No*	Yes	
2.7	Valve Position Monitor (4-20mA) Required	*Yes / No*	Yes	
2.8	Actuator Torque Monitor (4-20mA) Required	*Yes / No*		
2.9	Fieldbus Compatibility	*Yes / No*	No	
3	**Other Signals**			
3.1	Valve Position Monitor (4-20mA) Required	*Yes / No*	As per P&ID	
3.2	Actuator Torque Monitor (4-20mA) Required	*Yes / No*		
3.3	Fieldbus Compatibility	*Yes / No*	No	
4	**ENCLOSURE**			
4.1	Ingress Protection	*IP*	68	
4.2	Paint Colour			
4.3	Motor Class of Insulation			
5	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical detail sheet, the equipment to be provided will comply with the specified

Name (Print): _______________________________Signature: _________________________.

DATA SHEET No. DS-EL-0001
FIRE DETECTION AND SUPPRESSION

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**SYSTEM SUPPLIER AND INSTALLER DETAILS**			
1.01	Supplier			
1.02	Location of supplier			
1.03	Installer			
1.04	Location of installer			
2	**SYSTEM MANAGEMENT SOFTWARE**			
2.01	Manufacturer			
2.02	Product code			
3	**CONTROL PANEL**			
3.01	Manufacturer			
3.02	Type			
3.03	Model			
3.04	Supply voltage	*Vac/Vdc*	230Vac	
3.05	Operating Voltage	*Vac/Vdc*		
3.06	Addressable Panel	*Yes/No*	Yes	
3.07	Zone capacity	*No.*	4	
3.08	Number of loops	*No.*		
3.09	Maximum number of devices per loop	*No.*		
3.10	Maximum cable length per loop (at maximum device	*m*		
3.11	Number of relays	*No.*		
3.12	Battery back up	*Yes/No*	Yes	
3.13	Back-up period	*hr*		
3.14	Ingress Protection	*IP*	65	
3.15	Material	*Mild steel, 3CR12, Stainless steel*	Stainless Steel 316	
3.16	Panel colour		Red	
4	**LOOP CABLE**			
5	Manufacturer			
5.01	Type			
5.02	Size	*mm²*		
5.03	Fire rating	*PH*		
6	**I/O UNIT**			
6.01	Manufacturer			
6.02	Type			
6.03	Number of inputs	*No.*		
6.04	Number of outputs	*No.*		
7	**OPTICAL SMOKE DETECTOR**			
7.01	Manufacturer			
7.02	Type			
7.03	Addressable device	*Yes/No*	Yes	
7.04	Device colour		White	
7.05	Alarm indicator colour		Red	
8	**HEAT DETECTOR**			
8.01	Manufacturer			
8.02	Type			
8.03	Addressable device	*Yes/No*	Yes	
8.04	Device colour		White	
8.05	Alarm indicator colour		Red	
9	**EMERGENCY BREAKGLASS UNIT**			
9.01	Manufacturer			

DATA SHEET No. DS-EL-0001
FIRE DETECTION AND SUPPRESSION

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
9.02	Type			
9.03	Addressable device	*Yes/No*	Yes	
9.04	Colour		Red	
9.05	Mounting		Surface	
10	**SOUNDER/BEACON**			
10.01	Manufacturer			
10.02	Type			
10.03	Addressable device	*Yes/No*	Yes	
10.04	Device colour		White	
10.05	Alarm indicator colour		Red	
11	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified requirements

Name (Print): ___________________________ ***Signature:*** ______________________.

DATA SHEET No. DS-II-0001
CONTROL, INSTRUMENTATION AND DATA CABLES

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**CONTROL CABLES**			
1.1	Manufacturer			
1.2	Size	*mm^2*	1.5	
1.3	Operating Voltage	*V*	24VDC/230VAC	
1.4	Number of Cores	*No*	See Specifications	
1.5	Size	*mm^2*		
1.6	Conductor Type	*Cu/Al*		
1.7	Cable Type			
1.8	Full Load Current	*A*		
1.9	Armouring	*Yes/No*	Yes, SWA	
2	**INSTRUMENTATION CABLES**			
2.1	Manufacturer			
2.2	Operating Voltage	*V*	24VDC/230VAC	
2.3	Size	*mm^2*	1.5	
2.4	Cable Type		Twisted Pair	
2.5	Screened		Individually and Overall	
2.6	Armouring	*Yes/No*	Yes	
2.7	Amouring type		SWA	
3	**DATA CABLES: ETHERNET CU**			
3.1	Manufacturer			
3.2	Type		CAT6 STP	
3.3	Armouring	*Yes/No*	APL for outdoor cables	
3.4	Termination Type		RJ 45 (Moulded case type)	
4	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified

Name (Print): ________________________________ Signature: _________________________.

DATA SHEET No. DS-II-0002
CONTROL PANELS

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**PROGRAMMABLE LOGIC CONTROLLERS**			
1.1	Manufacturer			
1.2	Model			
1.3	CPU			
1.4	CPU configuration			
1.5	Digital Inputs	No.		
1.6	Digital Outputs	No.		
1.7	Analogue Inputs	No.		
1.8	Analogue Outputs	No.		
1.9	Spare I/O	%	30%	
1.10	Ports			
1.10.1	Ethernet	No.		
1.10.2	Serial	No.		
1.10.3	Other	No.		
1.11	Software			
1.12	All engineering software included with PLC	*Yes / No*	Yes	
1.13	Annual Software License renewal required	*Yes / No*		
1.14	Programming Language		IEC 61131	
2	**LOCAL CONTROL CONSOLE PANEL**			
2.1	Manufacturer			
2.2	Enclosure Material		Stainless Steel 316	
2.3	Epoxy Powder Coated	*Yes / No*	Yes	
2.4	Enclosure Colour		Electric Orange	
2.5	Ingress Protection	*IP*	65	
2.6	Enclosure Key Lock		Lockable keylocks plus unique operator SAP/password number	
2.7	Enclosure Mounting	*Floor Standing / wall mounted*	Floor Standing	
2.8	Cable Entry	*Top / Bottom*	Bottom	
2.9	Typical drawing included with specification	*Yes*	Yes	
2.10	Supply and Control Circuit Voltages	*V*	230VAC and 24VDC	
2.11	Wire Colours		as per spec	
2.12	Termination			
2.13	Glanding			
2.14	Power Supply Unit vendor preferences			
2.15	Uninterruptible Power Supply requirement	*Yes / No*	Yes	
2.16	Socket outlet required	*Yes / No*	Yes	
2.17	Physical Spare space	*%*	30	

DATA SHEET No. DS-II-0002
CONTROL PANELS

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
3	**HUMAN MACHINE INTERFACE (HMI)**			
3.1	Manufacturer			
3.2	Model			
3.3	Screen Size	*Inches*	min. 15"	
3.4	Screen Type		Display LCD, Colour TFT	
3.5	Resolution	*Pixels*	1,024 x 768 pixels, 16 M colors	
3.6	Touch Screen	*Yes / No*	Yes	
3.7	Type of Touch Screen	*Capacitive/ Resistive*		
3.8	Enclosure Rating	*IP*	66	
3.9	Position of Installation	*Inside Panel / Flush Fronted / Front Access*	Flush on top of Control Console	
3.10	Software			
3.11	**Datasheets included with tender**	***Yes / No***	**Yes**	
4	**UPS**			
4.1	Manufacturer			
4.2	Model			
4.3	Place of manufacture			
4.4	Type		Industrial inline double conversion with full static bypass	
4.5	Power	W	Load + 30%	
4.6	Backup Time	min	240	
4.7	Output Voltage	V	230V +-5%	
4.8	Nominal Frequency	Hz	50	
4.9	Output Waveform		Pure sine wave	
4.10	Number of Phases	1 or 3	1	
4.11	Communication		Ethernet	
4.12	Battery Life	Years	Min 10.	
4.13	Battery Type		Sealed, maintenance free, lead acid contained in	
4.14	Battery Charger			
4.15	**Datasheets included with tender**	***Yes / No***	**Yes**	
5	**MANAGED ETHERNET SWITCH**			
5.1	Manufacturer			
5.2	Model			
5.3	Ethernet Ports	*No.*	min 4	
5.4	Fibre ports (SFP)	*No.*	min 4	
5.5	Fibre Termination type		ST	
5.6	Mounting type		Din rail	
5.7	Power Supply	*VAC*	230V	
5.8	Speed	*Mbit*	1000	
5.9	**Datasheet included with tender**	***Yes / No***	**Yes**	

DATA SHEET No. DS-II-0002
CONTROL PANELS

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
6	SUPPLEMENTARY DETAILS			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified

Name (Print): ________________________________ Signature: _________________________.

DATA SHEET No. DS-II-0004
RADIO TELEMETRY

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**WIRELESS ETHERNET**			
1.1	Manufacturer			
1.2	Type		Digital UHF & Wireless Ethernet	
1.3	Standard		DFSK	
1.4	Protocol		DNP3/IP	
1.5	Data Rate	*kbps*	3.6 - 19.2	
1.6	Host Interface		Serial/Industrial Ethernet	
1.7	Operating Range		Up to 1km	
1.8	Radio Frequency	*MHz*		
1.9	Solar Power	*Yes/No*	No	
1.10	Power Output	*mW*		
1.11	Power Supply	*VDC*	12.0 - 24.0	
1.12	Surge Protection		Built-in	
1.13	Antenna			
2	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified

Name (Print): ________________________________Signature: __________________________.

DATA SHEET No. DS-II-0005
SCADA

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**DESKTOP COMPUTER - OPERATOR WORKSTATIONS**			
1.1	Manufacturer			
1.2	Model		Thin client	
1.3	CPU			
1.3.1	Type		Similar or equal to Intel I5, Gen 6+	
1.3.2	Speed	*GHz*	>3	
1.4	Memory	*MB*	>=8000	
1.5	Hard Drive Storage	*GB*	>500	
1.6	Operating System		MS Windows	
1.7	Optical Storage		DVD-RW	
1.8	Network Card		Ethernet 10/100/1000	
1.9	Graphics Card		>256MB, output to drive 2 x 23" display - ability to drive 2 screens.	
1.10	Graphics Card Ports		HDMI	
1.11	Keyboard		Yes	
1.12	Mouse		Yes	
2	**SCADA SERVER AND HISTORIAN SERVER**			
2.1	Manufacturer			
2.2	CPU			
2.2.1	Type		Similar or equal to Intel I7 or Xeon E2124	
2.2.2	Speed	*GHz*	>3GHz	
2.3	Memory	*MB*	>=16000	
2.4	Hard Drive Storage	*GB*	>1TB	
2.5	Motherboard		Industrial motherboard, conformal coating	
2.6	Hard drives		Raid hot swappable	
2.7	Power supplies		Raid hot swappabe	
2.8	Operating System		Windows server 2016 or later	
2.9	Optical Storage		DVD-RW	
2.10	Network Card		Ethernet 10/100/1000	
2.11	Graphics Card		>256MB, Dual output to drive 1 x 23"	
2.12	Keyboard		Yes - shared KVM	
2.13	Mouse		Yes - shared KVM	
2.14	Mounting Type		Rack mountable	
3	**SOFTWARE**			
3.1	SCADA software			

DATA SHEET No. DS-II-0005 SCADA				
	DESCRIPTION	UNIT	SPECIFIED	OFFERED
3.2	Number of Tags	*No.*		
3.3	Clients	*No.*	2	
3.4	Anti-Virus Software	*Yes / No*	Yes	
3.5	Mobile/Anywhere Clients	*Yes / No*	Yes	
3.6	Mobile/Anywhere Clients	*No.*	1	
3.7				
3.8	Historian Software			
3.9	Version			
3.10	Number of Tags	*No.*		
3.11	Anti-Virus Software	*Yes / No*	Yes	
4	**PRINTER**			
4.1	Manufacturer			
4.1	Model			
4.1	Type		Colour Laser	
4.1	Feeding Paper Size		A4	
5	**UPS**			
5.1	Manufacturer			
5.2	Model			
5.3	Place of manufacture			
5.4	Type		Industrial inline double conversion with full static bypass	
5.5	Power	W	Load + 30%	
5.6	Backup Time	min	30	
5.7	Output Voltage	V	230V +-5%	
5.8	Nominal Frequency	Hz	50	
5.9	Output Waveform		Pure sine wave	
6	Number of Phases	1 or 3	1	
6.1	Communication		Ethernet	
6.2	Battery Life	Years	Min 10.	
6.3	Battery Type		Deep cycle, Sealed, maintenance free, lead acid contained in	
6.4	Battery Charger			
6.5	Rack mounted	*Yes / No*	Yes	
6.6	**Datasheets included with tender**	***Yes / No***	**Yes**	
6	**COPPER DATA CABLES**			
6.1	Type		CAT6 STP	
6.2	Manufacture			
7	**SUPERVISORY ETHERNET SWITCH**			
7.1	Manufacturer			
7.2	Type		Managed	
7.3	Model			
7.4	Ports	*No.*		
7.5	Fibre ports (SFP/GBICs)	*No.*		
7.6	Rack mounted	*Yes/No*	Yes	
7.7	Power Supply	*VAC*	230V	
7.8	Speed	*Mbit*	1000	
7.9	PoE		PoE enabled	
7.10	Network management software			
7.11	**Datasheet included with tender**	***Yes / No***	**Yes**	
8	**SCADA CONTROL ETHERNET SWITCH**			

DATA SHEET No. DS-II-0005
SCADA

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
8.1	Manufacturer			
8.2	Type		Managed	
8.3	Model			
8.4	Ports	*No.*		
8.5	Fibre ports (SFP/GBICs)	*No.*	4	
8.6	Rack mounted	*Yes/No*	Yes	
8.7	Power Supply	*VAC*	230V	
8.8	Speed	*Mbit*	1000	
8.9	PoE		PoE enabled	
8.10	**Datasheet included with tender**	***Yes / No***	**Yes**	
9	**WORK STATION FURNITURE**			
9.1	Manufacturer			
9.2	Model			
9.3	**Sketch/Drawing included with tender**	***Yes / No***	**Yes**	
10	**SERVER RACK CABINET**			
10.1	Manufacturer			
10.2	Model			
10.3	Size	*U*	42	
10.4	Dimensions	*(W x L) in mm*		
10.5	Locakable	*Yes/No*	Yes	
10.6	Mounting type		Floor standing	
10.7	Power Distribution	Dedicated Multiplug / Hardwired	Dedicated Multiplug	
10.8	Material		Aluminium Frame, with epoxy powder coated plates	
10.9	Form Factor		19" Racks	
10.10	Door		Toughened smoked glass	
10.11	**Sketch/Drawing layout included with tender**	***Yes / No***	**Yes**	
11	**INDUSTRIAL RUGGED TABLET**			
11.1	Manufacturer			
11.2	Model			
11.3	Operating system		Windows based or Windows 10 IoT & Qualcomm Snapdragon	
11.4	CPU		Quadcore	
11.5	Memory	GB	2GB RAM	
11.6	Screen size	inches	min. 8	
11.7	Rubberised cover	*Yes/No*	Yes	
11.8	Battery Life	*hrs*	min. 8	
11.9	Weight	*kg*		
11.10	Hard Drive Storage	*GB*	>200	
11.11	Camera	*Yes/No*	Yes, colour	
11.12	Integrated barcode scanner	*Yes/No*	Yes	
11.13	Bluetooth and Wifi	*Yes/No*	Yes	
11.14	Ports		USB, HDMI	
11.15	Ingress Protection	*IP*	67	
12	**WIFI ROUTERS**			
12.1	Manufacturer			
12.2	Model			
12.3	LAN Ethernet Ports	*Yes/No*	Yes	
12.4	WAN Ethernet Ports	*Yes/No*	Yes	
12.5	Number of Wifi Device connection		8	

DATA SHEET No. DS-II-0005
SCADA

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
12.6	WIFI Frequency	*GHz*	2.4	
13	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified

Name (Print): ________________________________ Signature: _________________________.

DATA SHEET No. DS-II-0007
INSTRUMENTATION

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
1	**HYDROSTATIC LEVEL METER**			
1.1	Manufacturer			
1.2	Sensor Model			
1.3	Transmitter Model			
1.4	Number of Relay outputs	*No.*	>=2	
1.5	Detection Range	m		
1.6	Fieldbus Enabled	*Yes / No*	No	
1.7	Analog Input		4-20mA	
1.8	Surge Protection Required	*Yes / No*	No	
1.9	Local Indication Required	*Yes / No*	Yes	
1.10	**Additional datasheet from manufacturer included with tender**	***Yes / No***	**Yes**	
2	**OXYGEN METERS**			
2.1	Manufacturer			
2.2	Sensor Model			
2.3	Transmitter Model			
2.4	Number of Relay outputs	*No.*	>=2	
2.5	Detection Range	mg/l		
2.6	Fieldbus Enabled	*Yes / No*	No	
2.7	Analog Input		4-20mA	
2.8	Surge Protection Required	*Yes / No*	Yes	
2.9	Local Indication Required	*Yes / No*	Yes	
2.10	**Additional datasheet from manufacturer included with tender**	***Yes / No***	**Yes**	
3	**PRESSURE TRANSMITTERS**			
3.1	Manufacturer			
3.2	Sensor Model			
3.3	Transmitter Model			
3.4	Detection Range	kPa		
3.5	Number of Relay outputs	*No.*		
3.6	Fieldbus Enabled	*Yes / No*	No	
3.7	Analog Input		4-20mA	
3.8	Surge Protection Required	*Yes / No*	Yes	
3.9	Local Indication Required	*Yes / No*	No	
3.10	**Additional datasheet from manufacturer included with tender**	***Yes / No***	**Yes**	
4	**LEVEL SWITCHES: FLOAT**			
4.1	Manufacturer			
4.2	Model			
4.3	Type			
4.4	**Additional datasheet from manufacturer included with tender**	***Yes / No***	**Yes**	
5	**SURGE PROTECTION**			
5.1	Instrument Power Supply Circuits - Manufacturer			
5.2	Instrument Power Supply Circuits - Model			
5.3	Instrument Signal Loop - Manufacturer			
5.4	Instrument Signal Loop Circuits - Model			
5.5	Instrument Transducer Loop - Manufacturer			
5.6	Instrument Transducer Loop Circuits - Model			
6	**INSTRUMENT TRANSMITTER HOUSINGS**			
6.1	Manufacturer			
6.2	Material of Construction: *1.6mm Mild Steel / 2.0mm Mild Steel / Electro Galvanized / Stainless Steel / 3CR12 / Fibre Glass*		Stainless Steel 316	
6.3	Epoxy Powder Coated	*Yes / No*	Yes	
6.4	Colour		Electric Orange	

DATA SHEET No. DS-II-0007
INSTRUMENTATION

	DESCRIPTION	UNIT	SPECIFIED	OFFERED
6.5	IP Rating (Indoor)	*IP*	66	
6.6	IP Rating (Outdoor)	*IP*	66	
7	**SUPPLEMENTARY DETAILS**			

Regardless of any information provided in this technical data sheet, the equipment to be provided will comply with the specified require

Name (Print): _______________________________ Signature: _________________________.

aurecon

Engineering Standard

LV Switchgear & Controlgear Assemblies

25 June 2015

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Reference: EE-0010

Leading. Vibrant. Global.

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1. SCOPE

1.1 Application

1.1.1 This Standard Specification defines the requirements for the design, construction, installation, inspection, testing and commissioning of LV switchgear and controlgear assemblies (Assemblies), including distribution boards (DBs), motor control centres (MCCs), single standalone motor starters or controllers, control panels (either standalone or forming an integral part of the Assembly), control desks and consoles. Where this type of electrical equipment is incorporated within a plant supply package, the provisions of this Specification shall also apply.

1.2 General Requirements

1.2.1 An Assembly shall incorporate all components and equipment necessary to achieve the functionality defined in the Project Specification.

1.2.2 All materials, components, and equipment used in the manufacture of the Assembly shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification contains standard amendments and requirements which shall be applied to the referenced statutory and national standards. The project-specific requirements are provided in the Project Specification, which shall be read in conjunction with this Specification.

2.1.2 The design, construction, installation, inspection, testing and commissioning of the Assembly shall comply with all relevant statutory regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.

2.1.3 The manufacturer shall operate an approved, auditable quality assurance system covering the design, construction, inspection and testing of the Assembly.

2.2 Statutory Requirements

2.2.1 The Assembly as manufactured, and as installed on site, shall comply with the following:

a) Occupational Health and Safety Act of 1993

b) Manufacturer's specifications and installation instructions

2.3 Reference Standards

2.3.1 The Assembly and all its constituent components and equipment shall comply with the latest published edition of all relevant national standards, including the following:

Table 1: Reference Standards

Standard Number	Description
SANS 152	Low-voltage air-break switches, air-break disconnectors, air-break switch-disconnectors, and fuse-combination units
SANS 156	Moulded case circuit-breakers
SANS 172	Low Voltage Fuses
SANS 1091	National colour standards for paint
SANS 1973	Low-voltage switchgear and controlgear Assemblies
SANS 9000	Quality management systems
SANS 10108	The classification of hazardous locations and the selection of apparatus for use in such locations
SANS 10142	Standard Regulations for Wiring of Premises.
SANS 60044	Instrument Transformers
SANS 60204	Safety of machinery. Electrical equipment of machines.
SANS 60269	Low-voltage fuses.
SANS 60439	Low-voltage switchgear and controlgear assemblies
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 61558	Isolating transformers and safety isolating transformers.
SANS 60947	Low-voltage switchgear and controlgear
SANS 61000	Electromagnetic compatibility (EMC)
SANS 61643-1	Low-voltage surge protective devices Part 1: Surge protective devices connected to low-voltage power distribution systems

3. CONSTRUCTION REQUIREMENTS

3.1 General

3.1.1 Assemblies shall be designed and constructed to facilitate inspection, cleaning, repair and maintenance and to ensure absolute safety during operation, inspection and maintenance.

3.1.2 The arrangement of all circuit components / functional units shall be to the approval of the Engineer.

3.1.3 Where detailed in the Project Specification, spare compartments of a given size shall be provided within the enclosure. Each shall be equipped with a plain (i.e. un-punched) opening compartment door.

3.1.4 Every spare compartment shall be sized to house a triple pole and neutral incoming short circuit protective and isolating device, and shall be provided with a compartment earthing terminal.

3.1.5 Every spare compartment shall be provided with a gland plate or have access to an existing cable way within the enclosure.

3.2 Enclosures

3.2.1 All conductors and terminals that form part of the Assembly, including earth conductors and the Assembly earth bar, shall be enclosed within it. An earth stud may be provided as a part of a cable glanding facility.

3.2.2 Assemblies shall be constructed of materials capable of withstanding the mechanical, electrical and thermal stresses to which it may be subjected and the environmental and operating conditions likely to be encountered in normal service.

3.2.3 All boards, panels and cubicles shall be vermin and dust proof and the minimum degree of protection shall be:

Table 2: Minimum levels of ingress protection

Location	Description	Minimum rating
Indoor	Clean, dry areas (e.g. inside substations or motor control rooms)	IP44 (doors closed) IP2X (inter-compartment & doors open)
Outdoor	Located outside buildings	IP65 (doors closed) IP2X (inter-compartment & doors open)

3.2.4 Where heat is generated within the enclosure, it shall, where possible, be designed to dissipate naturally from the enclosure surface. Where this is not possible, ventilation openings shall be provided that maintain the highest practicable IP rating of the enclosure, subject to a minimum of IP42. Where cooling air is drawn into the enclosure, dust filters shall be provided where practicable.

3.2.5 For all variable speed drives and soft-starters (without bypass contactors) installed in indoor Assemblies, mini-extraction fans shall be installed inside the drive compartment to dissipate heat, without compromising the assembly's IP rating.

3.2.6 Particular attention shall be given to the ventilation of outdoor mounted boards, to eliminate build-up of excessive heat inside the boards caused by the solar radiation or internal heat generation.

3.2.7 Any internal partitions necessary to provide inter-compartmental segregation within the enclosure shall be of the same material as the sides of the enclosure.

3.2.8 All the surfaces of the enclosure, and of its constituent equipment and components shall be suitably protected against the effects of any likely atmospheric corrosion present at the operating location.

3.2.9 Purpose-made gland plates shall be protected against corrosion by electro-plating, galvanising, or be made of stainless steel and shall not be painted.

3.3 Construction of Free-Standing MCCs and DBs

3.3.1 Free-standing MCCs and DBs shall be constructed from steel with a structural frame permanently clad with side plates, so as to provide a multi-compartmented structure that is rigid with all doors and covers removed, and such that it will not deform during transport or installation. The enclosure doors and covers shall themselves be suitably braced so as to be rigid and not deform or flex when fully equipped and handled.

3.3.2 Each compartment formed within the enclosure for the purpose of housing components or equipment shall be provided with dedicated mounting plates for that purpose, which when removed do not expose any other compartment or live parts. Cabling shall only be terminated on or in the enclosure at gland plates provided for that purpose.

3.3.3 Horizontal wireways (top and bottom) shall extend through the width of each section.

3.3.4 The minimum metal thickness of the enclosure's constituent parts shall be as follows:

a) External cladding : 2 mm

b) Internal partitions: 1,6 mm

c) doors and removable panel covers: 2 mm

3.3.5 Free-standing Assemblies shall be mounted on and bolted to a rigid hot-dip galvanised steel 100 x 50 x 6 mm channel base.

3.3.6 The maximum height of any Assembly (including its base) shall be 2100 mm above finished floor level. No equipment other than busbars and/or inter panel control wiring shall be installed higher than 1900 mm above finished floor height, neither shall any equipment, other than cable glands and inter panel control wiring be installed lower than 300 mm above finished floor level.

3.3.7 Compartment single doors shall have vertical hinges mounted on their left hand side, and all doors shall have an angle of opening that is limited to 95 degrees. Where specifically agreed with the Engineer, a compartment single door on a front access only Assembly may be hinged on the right hand side if this will reduce the number of dropper / cable way chambers required. Wide compartments with dual doors shall open in wardrobe style, such that the second door is interlocked with the first.

3.3.8 Any cover which is required to be removed for adjustment, access, or maintenance and exceeds 0.75 m^2 in area, shall be provided with supporting lips, lift-off hinges, locating dowels, or handles, in order to facilitate safe removal and replacement.

3.3.9 Doors and any covers shall be fixed to the enclosure using captive bolt type fasteners, and each hinged door shall be capable of being removed, following disconnection of the electrical and earthing connections. Compartment doors shall be provided with securing catches which can be locked with a padlock, as follows:

a) door $\leq$ 400 mm high 1 No.

b) door $>$ 400 mm high 2 No.

c) door $>$ 1200 mm high 3 No.

3.3.10 The Assembly shall be constructed for front and rear access unless otherwise specified in the Project Specification. Where the Assembly shall be designed for front access only it shall be possible to gain access to every component, item of equipment, busbar and cable from the front (or for busbars, the top) of the enclosure; whether for maintenance or for replacement.

3.3.11 The form of internal separation (in accordance with SANS 60439-1) shall be as specified in the Project Specification. Form 3b or 4a as appropriate, shall be considered the minimum allowable internal separation for MDBs and MCCs.

3.3.12 Any apertures between compartments (including busbar compartments) through which the copper-work or cabling passes, shall be effectively closed off to minimise the possibility of an arc fault propagating between compartments.

3.3.13 Fixings for components, component mounting plates, etc. shall not penetrate another compartment containing live parts. Where self-tapping screws are used for component fixing they shall be of the thread forming or thread rolling type. Components, wiring, labelling, etc., shall only be located within compartments on a removable mounting plate, and in such a manner that facilitates easy inspection, maintenance, or removal and replacement, and without necessitating the removal or dismantling of any other components or wiring, or the use of special tools.

3.3.14 Unless detailed otherwise specified in the Project Specification, the Assembly shall be constructed so as to facilitate future extension by the addition of extra full height sections at either end. To accommodate this, any covers, fixings, etc. shall be flush with the end faces of the enclosure, and the end sections of busbars and earth bars shall be prepared for future extension.

3.3.15 The Assembly shall be constructed so as to permit it being split into sections in order to facilitate transportation and subsequent site erection. Each transportable section shall be labelled as to its shipping weight, shall be equipped with lifting eyes, which shall be removed on completion of the site erection.

3.3.16 All Assemblies shall have at least 15 % spare unequipped space complete with busbars, partitioning into compartments, etc. for future extensions.

3.4 Power distribution within an Assembly

3.4.1 The power distribution and circuit protective arrangements within an Assembly shall be designed so as to co-ordinate with the characteristics of the electrical system(s) connected to the incoming terminals of the Assembly, including emergency or temporary supplies and specifically noting the following:

a) maximum prospective RMS short circuit current from all simultaneously available sources of supply, together with any fault contribution from large motors directly connected to the Assembly

b) type of system earthing (i.e. TN-S, TT, etc.), the maximum available earth fault current, and the maximum earth fault loop impedance

c) up-stream protective device ratings and settings

3.4.2 Where this information is not stated in the Project Specification, it shall be obtained from the Engineer before the design of the Assembly commences.

3.4.3 Where the maximum prospective RMS short circuit current from all simultaneously available sources of supply, together with any fault contribution from large directly- connected motors, exceeds 10kA, the Assembly a Type Tested Assembly with stated deviations in compliance with SANS 1973-1.

3.4.4 Where the maximum prospective RMS short circuit current is 10kA or less, the Assembly shall comply with the requirements of SANS 1973-3.

3.5 Functional unit short-circuit protection and isolation

3.5.1 The Assembly shall be provided with separate incoming isolation for every electrical power system (including emergency or temporary supplies) connected to it.

3.5.2 The connection from the Assembly power distribution system into every compartment shall be terminated on a short circuit protection device, which may also incorporate a compartment isolating device, for short-circuit protection of all the components within a functional unit.

3.5.3 Every motor starter compartment shall be provided with a door interlocked isolation device, which shall isolate all sources of supply that enter the motor starter compartment. Where a functional unit; e.g. a motor starter, etc., comprises a group of interlocked compartments, the isolation device shall be located in the compartment receiving the supply.

3.5.4 Every compartment containing a distribution board or low voltage transformer shall be provided with an isolation device, which may be located in an adjacent compartment. For some compartments housing power monitoring equipment or instrumentation and process control equipment, it may be appropriate to provide a means of isolation within the compartment.

3.5.5 Unless separate fuses are used as the short circuit protection device, the isolation device and short circuit protection device shall be combined. Fuses may only be used to limit fault currents if approved by the Engineer.

3.5.6 Separate isolating devices shall be switch-disconnectors suitable for on-load switching. They shall be capable of being padlocked in the isolated / ‘off’ position at the compartment door, and at the isolating mechanism with the compartment door open. Any isolator mechanism extension shafts shall be provided with guide brackets as necessary to prevent excessive shaft deflection.

3.5.7 The compartment door shall be mechanically interlocked such that it shall not be possible to open the door when the isolating device is in the ‘on’ / ‘closed’ position or when the operating handle is padlocked in the ‘off’ / ‘open’ position. Where the means of isolation is only accessible from within the compartment, it shall be protected to a level of IP2X.

3.5.8 The following types of devices may be used:

a) Air circuit breaker (ACB) or moulded case circuit breaker (MCCB)

b) Fuse switch-disconnector

c) Switch-disconnector with separate fuses

3.5.9 All field circuits connected to a functional unit (e.g. valve actuators, limit switches, etc.) shall be provided with isolation either by or within that functional unit.

3.5.10 Where safety interlock keys are provided, e.g. to control device operation or to restrict access, they shall only be released in the safe condition, and shall be unique across that Assembly and any other Assembly installed at the same site.

4. ELECTRICAL COMPONENTS

4.1 Circuit Breakers (CBs)

4.1.1 Circuit breakers shall be either air circuit breakers (ACBs) or moulded case circuit breakers (MCCBs), as indicated on the single-line diagram for the Assembly.

4.1.2 CBs shall have a rated service short-circuit breaking capacity not less than that of the maximum prospective fault current at the point of connection in the power system, which shall be taken to be the busbar rated short-time withstand current specified for the Assembly Incomer CBs shall have a rated short-time withstand current and time not less than that of the busbars.

4.1.3 CBs with rated currents over 100 A shall have built-in protection , that will discriminate with both up-stream and down-stream protective devices, as appropriate to the application.

4.1.4 ACBs for incomer and feeder applications shall be fitted with adjustable electronic protection. MCCBs for incomer applications shall be fitted with adjustable thermal-magnetic or adjustable electronic protection.

4.1.5 An ACB shall incorporate padlockable cover(s) to permit the securing of the open, close, and trip actuators against inadvertent or unauthorised manual operation

4.1.6 Where an ACB or MCCB has electrically operated control circuits; e.g. opening, closing, tripping, spring charging, indication, etc., they shall be provided with individual fuse or MCB protection.

4.1.7 All ACBs and selected MCCBs (as indicated on the single-line diagrams) shall be of a withdrawable pattern with the number of poles indicated on the single-line diagram.

4.1.8 A withdrawable ACB or MCCB shall be provided with clearly visible carriage position indication (connected/disconnected/test), and shall be capable of being locked in each position. Mechanical interlocks shall be provided that only permit movement of the carriage whilst the main circuit contacts are in the 'OFF' position. It shall be possible to test the control circuits of an ACB with it partially or fully withdrawn.

4.1.9 As a withdrawable ACB or MCCB is being withdrawn, padlockable safety shutters shall automatically cover over the supply side and the load side fixed connections. These shutters shall be capable of independently being opened for testing purposes.

4.1.10 One (only) handling truck shall be provided suitable for each type of withdrawable ACB or MCCB supplied as a part of the Assembly, or as a part of any other Assembly supplied to the same building housing the Assembly.

4.1.11 Special maintenance tools, where required, shall be provided with each breaker.

4.1.12 Cables connected directly to CB terminals will generally not be permitted. Adequately sized cable/busbar adapters shall be provided.

4.2 Switch-disconnectors

4.2.1 The switch shall be suitable for the continuous rated duty of the circuit it controls.

4.2.2 The utilisation category of the switch-disconnector shall be AC23 for motor switching duties, and AC22 for switching of mixed resistive and inductive loads, with an appropriate utilization category (A for frequent switching and B for infrequent switching).

4.2.3 Rotary switch-disconnectors shall be provided with a ‘break-before-make’ operation for each pole. The rotary switch, or changeover switch formed by the proprietary interlocked interconnection of two switch-disconnectors or fuse switches, shall incorporate a centre ‘off’ position.

4.2.4 Switch-disconnectors for motor starter or variable speed drive duties, that incorporate a test position, shall enable the control circuit supplies while ensuring isolation of the main supply.

4.3 Fuse switches

4.3.1 Fuses and fuse bases shall comply with the requirements of SANS 172, and shall be provided with an indicating device to show the "blown" state of the fuse.

4.3.2 Only Motor circuit fuse links as defined in BS 88 shall be permitted on motor starting circuits.

4.3.3 Fuse current ratings shall be indicated on engraved 20 x 12 mm white-black-white traffolyte labels in 4 mm figures. The labels are to be fitted at the fuse bases and shall not be obscured by wiring.

4.3.4 This shall comprise a moulded carriage accommodating either HRC fuses or solid links, and shall provide for a switched neutral where required.

4.3.5 Provision shall be made for the following:

a) Double break contacts on each pole.

b) Arc barriers on each pole.

c) IP2X protection in either state.

d) Silver plated copper contacts.

e) Neutral link where required.

f) Mechanically operated ON/OFF indicator.

g) Auxiliary switch facility.

h) Full interchangeability of equivalent rated units

4.3.6 The continuous thermal rating and the circuit fuse rating shall be indicated adjacent to the switch.

4.3.7 The minimum utilisation category of the fuse switch shall be AC23 for motor starting duties, and AC22 for power distribution only duties.

4.3.8 All fuses used on LV circuits shall be HRC cartridge type fuse links complying with both SANS 60269 and BS 88 Part 6 / BS 88 Part 2 Section 2.2 (fuse links with bolted connections), except as follows:

a) semiconductor protection fuses recommended or provided by the manufacturer of any power electronics incorporated into the Assembly;

b) sub-distribution fuses for extra-low voltage control circuits in ICA equipment compartments.

4.3.9 The sub-distribution fuses for control circuits (mentioned above) shall be miniature ceramic cartridge fuses complying with BS 2950. They shall be mounted in knife-edge (‘swinging blade’) disconnect type DIN rail mounted terminals. Knife-edge disconnect type terminals shall similarly be used for neutral links.

4.3.10 Neutral and earth link holders shall be non-interchangeable with fuse holders, and fuse and link holders shall be segregated according to circuit voltage.

4.3.11 Where HRC cartridge type fuse links do not form an integral part of an item of equipment such as an enclosed transformer, a fuse switch, etc., they shall be mounted in all-insulated fuse carriers fitted into fuse holders. An associated neutral circuit shall be provided with a solid copper link, which shall be mounted in an identical manner adjacent to the phase circuit fuse holders.

4.3.12 Fuse and link bases shall contain insulating shrouds, that can only be removed using a tool. A fuse or link shall only be capable of insertion into its base using the appropriate carrier. Fuse and link carriers and holders shall be coloured as follows:

a) fuse links: black

b) neutral links: white

c) earth links: green

4.3.13 A spare set of all fuse types and ratings used within a functional unit shall be mounted within each functional unit.

4.3.14 Combination fuse switches shall comply with SANS 152 and shall be of the independent manual operation type and shall afford minimum protection of IP21.

4.4 Switch operator

4.4.1 Switch operating mechanisms shall include operators for fuse switches, switch-disconnectors, moulded case circuit breakers and motor protection circuit breakers for Assemblies.

4.4.2 Switch operating mechanisms shall be door mounted and the switches shall be fixed mounting.

4.4.3 Switch operating mechanisms shall positively engage with the switch shaft when the door is fully closed and shall be so interlocked with the door so that:

a) It shall not be possible to gain access via a cover or door to any live points unless the switch is in the open position.

b) It shall not be possible to re-close the door or cover unless the switch is in the open position. Operation of the switch with the door open is permissible.

4.4.4 Clear indication shall be given, both with the access cover or door open or closed, as to whether the switch is in the open or closed position. Colour indication alone will not be acceptable.

4.4.5 Operating handles shall be pad lockable in the “off” / “open” position. The mechanisms shall accept not less than two padlocks each having a shackle diameter of 6 mm.

4.4.6 Any isolator mechanism extension shafts shall be provided with guide brackets as necessary to prevent excessive shaft deflection.

4.5 Contactors, Relays and Timers

4.5.1 Contactors and relays shall be selected so as to be suitable for the foreseeable operating duty (utilisation category) and operational frequency. They shall operate reliably under reduced voltage conditions by closing (i.e. pulling in and holding) at 85 %, and remaining closed at 60 %, of the rated coil voltage, and shall be suitable for continuous operation at 110 % of the rated coil voltage.

4.5.2 Contactors shall comply with SANS 60947-4-1, and shall be electro-magnetically operated air-break multi-pole block type construction. They shall readily accept a wide variety and configuration of auxiliary contact blocks, which shall have their terminals protected to IP2X.

4.5.3 Relays and timers shall be totally enclosed plug-in devices. The bases shall be keyed in order to differentiate between differing relays and timers, and their differing coil / electronics operating voltages, and to prevent incorrect insertion. Bases shall be fitted with retaining clips, and each relay / timer shall have its pin configuration printed on the side of its casing.

4.5.4 Relay / timer bases shall have screw clamp type terminals protected to IP2X, which shall be accessible with a screwdriver whilst the relay / timer is plugged in.

4.5.5 Relays shall be provided with a transparent enclosure, visual indication that the relay is in the energised and closed state, and a manual test button.

4.5.6 Timers shall operate electronically or be synchronously driven, and shall be provided with linearly calibrated time interval scales. The smallest indicated time interval shall be 10 % (or less) of full scale, with a repeatability of 1 % (or better) of full scale. Timers shall be provided with ‘energised’ and ‘timed out’ indicators.

4.5.7 Where timers require to be viewed by operators, they shall be flush front of panel mounted behind a transparent lockable cover.

4.5.8 Contactors shall be satisfactorily withstand the thermal and dynamic effects arising from the magnitude and duration of through fault currents dictated by the characteristics of the associated protective devices and shall be selected in accordance with the kW/current rating.

4.5.9 Contactors shall be triple-pole electromechanically operated air-break type, held in or latched pattern as specified.

4.5.10 Contactors shall be classified as utilisation category AC3 uninterrupted duty for motor starting and as utilisation category AC1 intermittent duty, Class 1, 60 % for heater duty.

4.5.11 Contactors shall be fitted with the required auxiliary contacts. These shall be rated at not less than 6 A and shall be positively driven in both directions.

4.5.12 Auxiliary relays for control purposes shall be of the multiple pole type and shall preferably possess the feature of field convertible contact configuration.

4.5.13 Plug-in type relays shall have:

a) Positive-acting mechanical retaining clips. Contact friction alone as a retaining method is unacceptable.
b) A keyed member on plug and socket sides to prevent incorrect insertion.
c) Clear and indelible markings on both the relay and its base indicating the circuit reference in conformity with the associated circuit and connection diagrams.

4.5.14 Auxiliary time delay relays shall be of electronic or synchronous motor-driven type and the time setting shall be infinitely adjustable over the range of 5 - 100 % of the maximum delay. Timing relays deriving the delay function by thermal or pneumatic means will not be acceptable.

4.5.15 Auxiliary relays shall have a minimum of 4 individual contacts and shall preferably have the facility to add an extension block with an additional four (4) individual contacts.

4.6 Control switches and pushbuttons

4.6.1 Control selector switches shall be of a rotary spring loaded type, with an AC11 rating, and shall have clearly identified switch positions. Where switches are lockable, the key shall be held captive in the abnormal or over-ride position.

4.6.2 Pushbuttons shall comply with SANS 60947-5-1 and shall be of a 22 mm diameter, flush bezel type.

4.6.3 Emergency stop pushbuttons shall be of a mushroom headed push to stop, stay-put and twist-to-release type. Key type release buttons shall not be used.

4.6.4 Pushbuttons shall be coloured as follows:

Table 3: Pushbutton colours

Function	Colour
Start	Green
Stop	Red
Reset	Black
Emergency stop	Red
Lamp test	Black
Close / Down	Green (or black)
Open / Up	Green (or white)
On	White (or green)
Off	Black (or white)
Forward	Green (or white)
Reverse	Green (or black)

4.6.5 Pushbuttons shall be of the one-hole fixing, oil tight pattern.

4.6.6 Operators (and the mating holes) shall be keyed to prevent rotation of the assembly in the panel.

4.6.7 Contacts shall be adequately rated for the circuit duty but shall not be less than 10 A, 230 V AC or 120 V DC rating.

4.6.8 In addition the operator shall carry an internationally acceptable symbol indicating its function or shall have mounted immediately above it a clear legend of its function or action.

4.6.9 Operators initiating a motion or circuit closure shall be flush with the surrounding bezel, while operators stopping a function or opening a circuit shall project beyond the bezel.

4.6.10 Operators providing a selective function e.g. local/remote or auto/manual, shall operate in a semi-rotational manner with equal angular displacement about an imaginary vertical centre line.

4.7 Indicating lamps

4.7.1 Indicating lamps shall be suitable for use on either 230 V AC or 24 V DC control supplies, and shall be light emitting diode (LED) type. Lamps suitable for use on 230 V AC shall incorporate a step-down transformer. Indicating lamps shall be continuously rated for a voltage of 10 % in excess of the rated voltage.

4.7.2 Lamps shall comprise 22 mm diameter units incorporating either a multi-cluster array of LEDs or a single high intensity surge protected LED; replaceable from the front of panel without any special tools.

4.7.3 Indicating lamps shall render good visibility under conditions of an ambient illumination level of 400 Lux.

4.7.4 Lamps shall be provided with one of two indicator lamp colour coding schemes as follows:

a) a primary colour coding scheme, in compliance with IEC 60073, or

b) a secondary colour coding scheme; which although not standard, is required in order to harmonise with existing operational equipment.

4.7.5 Unless detailed otherwise in the Project Specification, the Assembly shall be provided with indicating lamps coloured in accordance with the primary colour coding scheme, which shall be as follows:

Table 4: Primary colour coding scheme

Function	Colour
Dangerous condition	Red
Emergency / hazardous condition	Red
Emergency stop operated	Yellow
Impending critical condition	Yellow
Alarm / abnormal condition	Yellow
Tripped / fault condition	Yellow
Warning	Yellow
Normal condition	Green
On	Green
Running	Green
Closed condition	Green
Mid position / mid travel	Green + White
Open condition	White
Available / auto available	White
General indication / monitoring	White
Mandatory operation required by operator	Blue

4.7.6 Where specified in the Project Specification, the manufacturer shall supply an additional number of loose indicating lamps (or their coloured lenses) of a specified type and coloured in accordance with the primary colour coding scheme, and shall retrofit these to specified existing assemblies.

4.7.7 Where an Assembly is provided that incorporates lamp colours in accordance with the secondary colour coding scheme, the manufacturer shall also supply an additional quantity of loose indicating lamps. There shall be a sufficient quantity of the required types and colours; coloured in accordance with the primary colour coding scheme, to permit a third party to retrofit them the Assembly at a later date in order to bring it into compliance with the primary colour coding scheme. In addition, the final drawings for the Assembly shall not detail the colour of any indicating lamp that does not comply with the primary colour coding scheme.

4.8 Power measuring instruments and current transformers

4.8.1 The Project Specification states which functional units shall be provided with power/current and voltage measuring instruments, the type, and the facilities required.

4.8.2 Display instruments used to indicate voltages and currents shall normally be analogue instruments, shall comply with IEC 60051, be of the low-impedance type and have an accuracy class of 1.5. They shall be flush front of panel mounted with a 90° quadrant minimum scale length, and be DIN96 size for power distribution functional units, and DIN96 or 72 sized for motor starter functional units.

4.8.3 External zero adjustment shall be possible on all indicating instruments to facilitate adjustment without dismantling the instrument.

4.8.4 Instruments shall be scaled to 120 % of the anticipated designed indication. Ammeters shall be provided with compressed scales to accommodate motor starting or other in-rush currents, and ammeters monitoring motor currents shall be provided with an adjustable red pointer to indicate full load current.

4.8.5 Meters and relays shall be capable of withstanding, without damage, the secondary currents associated with the maximum available through fault current.

4.8.6 Instruments shall be provided with shrouded connections to their rear, and ammeter circuits with a full scale deflection in excess of 25 A shall be connected via current transformers (CTs). Apart from CT and ammeter circuits, instrument circuits shall be fused.

4.8.7 Instruments used in power distribution circuits shall be flush front of panel mounted and shall provide selectable front of panel digital display of at least the following measurements:

a) voltage between phases and between phases and neutral

b) current in each phase

c) power (kW)

d) kVA

e) power factor

f) consumption (kWh)

4.8.8 They shall provide data output signals for presentation to PLC, SCADA, telemetry, etc.

4.8.9 Where the Project Specification indicates that instruments shall provide fieldbus communication with a control system, this shall be via an open protocol compatible with the proposed control system.

4.8.10 Run hour meters shall be of a 5 digit minimum non-re-settable odometer type, with visual indication of operation, and a minimum resolution of one hour.

4.8.11 Current transformers (CTs) shall be air insulated, shall comply with SANS 60044, and shall have short circuit ratings in excess of those prevailing at the point of connection. They shall bear individual rating plates, which shall clearly identify the winding polarities (primary or secondary), together with the connection details of any multi-ratio windings.

4.8.12 Current transformer accuracy classes shall be selected as follows unless otherwise indicated on single-line diagrams:

Table 5: Transformer accuracy classes

Type of circuit	Class	Comments
Indication	3 or 5	To match the % accuracy of the instrument
Measurement	0.5 or 1	To match the % accuracy of the instrument
Motor protection	10P10	Or as required by protection device manufacturer
Power system protection (e.g. IDMTL)	10P20	Or as required by protection device manufacturer
Power system unit protection (high accuracy; e.g. REF, generation, unit protection)	PX	As specified by protection device manufacturer

4.8.13 One pole of the secondary winding of each CT (or group of CTs) shall be connected to earth via a link. All connections to the CT secondary winding shall be made via a proprietary shorting terminal test block. Provision shall be made for attaching test links.

4.8.14 Current transformers shall be of the low-impedance type and shall, where ratio, class and output requirements permit, preferably be of the ring-type bar-primary design.

4.8.15 Current transformers shall be rated to withstand the thermal and magnetic stress resulting from the maximum available through fault current.

4.8.16 Bridging terminals for current transformers shall be provided at the outgoing terminals where external connections are required. In addition, terminal blocks shall be provided to permit secondary injection tests on protective relays.

4.9 Control-circuit and auxiliary supply transformers

4.9.1 Voltage transformers shall be designed, constructed and tested in accordance with the requirements of SANS 60044.

4.9.2 Voltage adjustment over the range 95 - 105 % of nominal ratio shall be provided by off-circuit tappings.

4.9.3 Transformers shall be provided with isolating switches on the HV side and with protection on both the HV and LV sides.

4.9.4 Voltage transformer primary and secondary windings shall be protected by fuses.

4.9.5 The protection on the HV. side shall be rated sufficient to withstand inrush currents.

4.9.6 Control transformers shall be rated as follows:

a) Sum of sealed-in burden of all contactors, relays, timers and lamps fed from that unit; plus

b) Pickup burden of largest Contactor fed from that unit; plus 10 %.

4.9.7 The regulation on closing the largest circuit with all the loads except that of the largest load, or if there is more than one, one of the largest loads, imposed on the transformer, shall not exceed 5 %.

4.9.8 One side of the transformer secondary winding, or the star point thereof, shall be connected to earth via a removable bolted link.

4.9.9 Voltage transformer nameplates shall be fixed in a position so that details can easily be read when fitted in the cubicle.

4.10 Capacitors

4.10.1 Capacitors shall be of the non-toxic, dry, self-healing, metallised film type, and comply with SANS 60831.

4.10.2 Capacitors shall be fitted with a means of electrical discharge to reduce the residual voltage to less than 60 V within 5 seconds of being switched off.

5. MOTOR STARTER FUNCTIONAL UNITS

5.1 General requirements

5.1.1 Motor starter functional units shall be provided as indicated on the single-line diagrams and as detailed in the Project Specification, and all equipment, components, and wiring shall be included to achieve the required functionality. The following methods of motor starting shall be considered, where the selection is the Contractor's responsibility, to provide the required functionality:

a) direct on line (DOL)

b) star/delta (open/closed transition to suit application)

c) line reactor

d) auto-transformer (closed transition)

e) soft starters and variable speed drives using power electronics

5.1.2 Where specified in the Project Specification, integral direct on line starters complying with SANS 60947-6-2, shall be used for motor starters of less than 10 kW. The integral motor starter shall incorporate an isolation device, a short circuit protective device, a contactor and overload protection with Type 2 coordination.

5.1.3 Each motor starter shall be provided with an isolation and short circuit protection device.

5.1.4 Motor starter contactors, short circuit protective devices, and thermal overloads shall be selected so as to provide Type 2 Co-ordination in accordance with SANS 60439-4-1. The minimum starter contactor utilisation category shall be AC3.

5.1.5 Motor circuit residual current protection shall only be provided where necessary to discriminate with upstream protection, where the power supply is derived from a TT source, or where specified in the Project Specification.

5.1.6 Contactors used where simultaneous closure would be dangerous, e.g. in reversing, star-delta, or closed transition starters, shall be provided with both mechanical and electrical interlocks.

5.1.7 Where components with short time ratings are used, e.g. resistors, transformers, etc., they shall be provided with hardwired temperature monitoring circuits, arranged to trip the line contactor if their thermal limits are reached.

5.1.8 Withdrawable starters shall be provided with suitable interlocks to prevent chassis withdrawal or insertion when the starter isolation device is in the "on" position.

5.2 Functional requirements

5.2.1 Every individual motor starter unit shall include all equipment, components and wiring necessary to safely and reliably operate the driven plant item. It shall be possible to manually operate plant item from the front panel of its functional unit, notwithstanding any failure or de-selection of any automatic control system, networking / communication facility, PLC, SCADA, or telemetry system. In order to achieve this, the appropriate push buttons / keypads and indicators shall be provided front of panel.

5.2.2 If the power supply fails whilst a motor is running, the line contactor shall open. On restoration of the power supply, the motor starter shall immediately be made available to re-start the motor without manual attendance or intervention on receipt of a start command (be it initiated manually or automatically). However, where a hardwired automatic control facility is available, a power-on delay timer (adjustable between zero and 60 s) shall be provided in the hardwired circuit.

5.2.3 Where a ‘healthy' signal is required, it shall confirm that the functional unit isolation device is closed, the starter control supply is healthy, no fault condition exists, emergency stop(s) are released, the local isolator (where fitted) is closed. The ‘healthy' signal shall be used to provide the ‘drive available’ input signal to any automatic control schemes or automatic duty selection routines.

5.2.4 Each functional unit shall provide any automatic control schemes (including auto duty selection routines) with the following status signals as a minimum, as well as all others as specified in the Project Specification:

a) Manual/auto mode

b) Running

c) Tripped

d) E/Stop activated

5.2.5 Each motor starter shall be provided with an emergency stop circuit, which together with its components shall comply with BS EN 418. A field ‘twist to reset’ emergency stop button shall be provided. On operation of the emergency stop circuit, the motor line contactor shall immediately open, and the emergency stop circuit shall lock out until it is reset. A front of panel ‘emergency stop operated’ indication lamp and a status signal for PLC monitoring shall be provided. A composite starter may have a common emergency stop circuit controlling all of its constituent drives.

5.2.6 Where identified in the Project Specification, specific process or driven plant interlocks shall be hardwired into the motor starter, and when operated, shall stop and inhibit the drive.

5.2.7 Front of panel pushbuttons shall be provided for manual start (forward, and where applicable; reverse), and manual stop. A front of panel control selector switches shall be provided for ‘Manual / Off / Auto’ or ‘Remote / Local’ as specified in the Project Specification.

5.2.8 Front of panel indicator lamps shall be provided for ‘running’ and ‘tripped’, and an ammeter shall be provided for motor circuits ; other front of panel indications e.g. specific fault indication lamps , hours run meter, number of starts counter, etc. shall be as specified in the Project Specification.

5.3 Motor protection

5.3.1 As a minimum, every motor starter circuit shall be provided with a thermal overload unit connected to monitor the current in each energised winding of the motor. Unless otherwise specified in the Project Specification, motors of over 30 kW shall be provided with electronic overload protection, and motors of over 75 kW shall be provided with electronic motor protection relays. Intelligent multifunction electronic relays shall be provided if specified in the Project Specification.

5.3.2 Thermal overloads shall be scaled and adjustable such that the motor rated current is mid-range, and shall provide a temperature compensated thermal element for each supply phase to the motor. The unit shall provide single phasing protection, and incorporate auxiliary tripping contacts with a manual test facility. The unit shall be capable of being manually or automatically reset (set to auto). Unless otherwise specified in the Project Specification, thermal overloads shall be trip class 10.

5.3.3 Electronic overload units shall incorporate the features required of a thermal overload, together with provision for the adjustment of tripping and reset times. In addition, stalled rotor protection shall be provided, together with integral thermistor protection where required. Where required, electronic overloads shall be suitable for use in conjunction with power electronics (soft starters or variable frequency converters).

5.3.4 Electronic underload protection shall be provided for all centrifugal pump, fan, or directly driven mixer motor circuits above 30 kW. When detecting underload, the device shall measure the true motor power (and not just the phase angle), shall be configured to detect an unloaded running motor condition, and shall incorporate start delay, motor trip, and manual / auto reset (set to auto) facilities. The unit shall incorporate a digital percentage load display.

5.3.5 Where required on drives of less than 30 kW, the underload unit shall be provided with overcurrent protection providing the same facilities as a thermal overload. When required on larger drives, underload protection shall be provided as an integral part of an electronic overload or motor protection relay, and where applicable shall be suitable for use in conjunction with power electronics.

5.3.6 Motor thermistor and RTD (PT100) relays shall be provided for motors which have been specified to be fitted with thermistors or RTDs.

5.3.7 Motor starter functional units for immersible/submersible pumps shall incorporate all the standard integral motor and pump protection, such as water ingress, temperature of windings and bearings, vibration, etc.

5.3.8 All protection devices shall operate in a fail safe manner via electrically maintained relays which de-energise on a fault condition. On sensing a trip condition, the devices and relays shall electrically lock-out the emergency stop circuit, and shall be reset manually using a front of panel common fault reset pushbutton. In addition, they shall automatically reset on control supply switch on and upon power restoration in the event of a power loss.

5.3.9 Electronic motor protection relays and digital overload and underload devices which provide operator interfaces shall have front of panel mounted displays and controls.

5.4 Test circuits

5.4.1 The motor starter control circuit supply shall be provided with a functional test facility, whereby the functionality of the control circuit and its equipment and components can be fully demonstrated with the compartment door(s) open, but whilst the motor circuit supply remains isolated at the functional unit isolating device.

5.4.2 A control selector switch shall be provided for ‘Normal/Test’ selection inside the relevant compartment

5.4.3 The test supplies shall be arranged to be de-energised when the motor circuit supplies are energised. The test supply shall be provided with short circuit protection, and shall be capable of isolation.

6. BUSBAR AND BUSBAR TRUNKING

6.1.1 The main distribution circuit through the Assembly shall comprise a main and distribution busbar system, comprising of 3 phase and neutral busbar system. The rated current of the busbar system shall match the rating of the main incomer

6.1.2 All main and distribution busbars, risers and droppers shall be air-insulated and shall be fabricated from hard drawn, high-conductivity copper. Aluminium busbars will not be permitted. Busbars shall be tinned for waste water treatment works (WWTW) applications. If pre-tinned copper work is provided, cut surfaces may remain bare, providing the current path is unaffected and suitable contact lubricants are used before tightening joints.

6.1.3 Main busbars shall be enclosed together within the top of the Assembly. No other conductors shall be run in the busbar compartment. Access to the busbars shall be through covers, requiring the use of a tool for removal. All internal fixings shall be held captive. No components shall be placed in a busbar compartment.

6.1.4 Main and distribution busbars shall be continuous over each section, extending to over the full length of the Assembly with the same current rating and cross-sectional area throughout their length.

6.1.5 Main busbars, distribution busbars and all flexible connections, shall be adequately sized, braced and supported to withstand any electromagnetic forces and thermal effects to which they may be subjected, including the occurrence of fault currents, up to the full fault levels specified.

6.1.6 The vertical riser buses shall be copper full height and rated for the section total load. Small openings in the vertical barriers shall permit the plug-on control unit contacts to pass through and engage with the vertical bus bars. Unused plug-on openings in the vertical barriers shall be equipped with plastic snap-in closing plugs.

6.1.7 All busbar connections shall use joints secured against loosening. Joints and Tee-off connections in busbars shall be made by means of high-tensile bolts, nuts and approved locking washers. A minimum of two such bolts shall be used per joint or tee. The joints shall not be taped in order to facilitate visual inspection and checking of bolt tensions. The joint contact areas shall be smooth, very flat and polished or tinned for dry jointing.

6.1.8 Busbars shall be provided with phase colour markers, red, white, blue (and black in the case of four wire systems). Such colour identification may take the form of coloured bands at intervals along the busbar run of not more than 800 mm. The combined width of the colour bands per phase shall not be less than 300 mm per 800 mm busbar length. The use of the convention, Red, Rear, Right shall be employed

6.1.9 The maximum length of any cable connections from a busbar shall be 1000 mm.

6.1.10 A cabled ‘busbar’ system of the specified radial or closed ring arrangement may be offered as an alternative to a conventional system if:

a) The Assembly has a rated short-time withstand current or rated conditional short-circuit current not exceeding 10 kA; or

b) The Assembly is protected by current limiting devices having a cut-off current not exceeding 17 kA at their rated breaking capacity.

6.1.11 This will generally mean that the rated current of such an Assembly will be less than or equal to 100 A.

7. INTERNAL WIRING AND FIELD CONNECTIONS

7.1 General

7.1.1 All wiring within the Assembly shall run directly between terminals, without any joints or other connections. Wiring shall be carried out using multistrand, single-core PVC-insulated copper conductor, 660/1 000 V grade (minimum), to SANS 1507, sized and derated where required for the currents to be carried. Single-strand conductor shall not be used and no conductor shall be less than 1,5 mm^2 cross-sectional areas.

7.1.2 Field wiring connections will be identified by others using the field device tag references. This information will be provided by the Engineer, and the Contractor shall use these field identifiers when identifying the compartment field terminations.

7.1.3 Wiring layout shall permit alterations to individual circuits without requiring shut down of the complete Assembly.

7.2 Cable Ways inside Assembly

7.2.1 All bus wiring and interconnections between compartments within the Assembly shall be contained within the enclosure, and shall be segregated in wire-ways separate from other compartments. Where such wiring is terminated in a compartment, it shall be segregated from all other wiring in that compartment. All wiring and cabling entering or leaving a compartment or passing through a partition shall do so via a permanently fixed bush.

7.2.2 Wiring between components shall be:

a) carried out in a neat and systematic manner

b) contained in non-metallic trunking

c) Run to compartment doors in spiral wrapping.

7.2.3 Any wire containment system shall securely locate the wiring, and provide 25 % spare capacity on completion. Cableways shall have furthermore sufficient space to enable the installation and removal of any cable without the need to remove any other cable or component. Cableways shall incorporate adequate facilities to locate and support the cables.

7.2.4 Wiring on compartment doors shall be similarly supported, and shall be provided with support and protection across the door to compartment side wall transition, whilst permitting the door to be fully opened without straining the wiring. Wiring system accessories shall not deteriorate with heat or propagate flame.

7.2.5 Wiring shall be segregated according to need; circuits that enter the compartment without isolation shall be separately segregated and loomed with spiral wrapping and identified. Control circuits shall be wired in twisted pairs or screened cables, and together with data network cabling, shall be physically segregated from power circuits by barriers. If lightning and/or surge protection measures have been used to protect individual circuits, these circuits shall be segregated from the wiring of other unprotected circuits.

7.2.6 Cable-ways or chambers shall not contain any equipment or components.

7.2.7 Where field cables are terminated other than in the base of the enclosure, cable-ways or cable chambers shall be provided to transport the cables through the enclosure to the compartment or cable box at which they are glanded or terminated. Careful thought should be given to the termination of power cables and their location within the assembly.

7.3 Gland Plates

7.3.1 All field cables and wiring shall enter the enclosure through gland plates, which shall be located so as to facilitate the spreading of cable cores.

7.3.2 Gland plates shall be rigidly supported and maintain the IP rating of the enclosure

7.3.3 Gland plates and cable boxes shall minimise the effects of eddy currents and be suitable for the type of cable used. Single core cable gland plates shall be made of non-magnetising material.

7.3.4 Gland plates for bottom access cabling shall be located at least 300 mm above the finished floor level.

7.3.5 Each compartment gland plate shall be an integral part of the construction of that compartment

7.4 Identification

7.4.1 All wires shall be identified at both ends using colour coded alpha-numeric ferrules. Within a compartment, a wire shall have the same identifier at both ends; and this identifier shall not be duplicated within a functional unit.

7.4.2 Components and wiring shall be installed such that the identification of every wire is clearly visible and readily accessible on completion of the Assembly installation at site. Horizontal wiring identifiers shall be read left to right, and vertical wiring identifiers shall be read bottom to top.

7.4.3 All conductors shall be identified in conformity with the approved circuit and connection diagrams. No number shall be used more than once in each panel except where electrically identical. Wires/conductors shall have the same number on either end of the wire and all wires which are electrically identical shall have the same wire number

7.4.4 Circuit wiring shall be coloured in accordance with the following:

Table 6: Colour code for wiring

Wire colour	Function
Red (white, blue)	Red (white, blue) phase connections in current and voltage-transformer circuits or connections in red (white, blue) phase power circuits
Black	Neutral (star-point) connections whether earthed or unearthed insulated wires
Red / black	Connections in AC control circuits (black = neutral)
Red / black	Connections in DC control circuits (black = negative)
Green and yellow	Earth wires and earthing

7.4.5 Power-circuit conductors shall be coloured according to the phase to which they are connected.

7.5 Termination

7.5.1 Wiring shall be terminated using crimped cable ends, lugs or any other approved method that is appropriate for the conductor size and type of termination. All of the strands forming the conductor shall be connected at the point of termination. Soldered connections shall only be used on electronic equipment where it is not practicable to use any other termination method.

7.5.2 Wiring with a cross section area of less than or equal to 6 mm^2 shall be terminated in terminals mounted on DIN rail. Wiring with a cross section area of greater than 6 mm^2 shall be terminated in bolted terminals.

7.5.3 All wiring entering or leaving a compartment shall do so via terminal rails, with the exception of specialised signal or data circuits, which may be cabled directly to dedicated connections on electronic equipment located at the periphery of the component mounting plate.

7.5.4 The conductor shall be clamped in such a manner that the captive clamping screw does not come into contact with the conductor. Alternatively, screw-less spring clamp tensioning terminals may be used to terminate single conductors of up to 10 mm^2. Conductors of cross-section above 16 mm^2 shall be terminated using stud type terminals; similarly mounted and grouped on DIN rail.

7.5.5 No more than two conductors shall be connected to one side of a terminal. Where it is necessary to connect adjacent terminals together, proprietary shorting bars or combs shall be used.

7.5.6 Spare cores shall be terminated at both ends or tied back, but shall not be cut short.

7.5.7 All terminals shall be protected to IP2X, including stud type terminals; which shall be shrouded to achieve this. Terminals shall be segregated according to function and operating voltage; by grouping or by terminal rail mounted partitions or barriers. All stud type terminals shall be provided with individual segregating barriers.

7.5.8 All circuit terminal rails shall include 10 % spare space.

7.5.9 Terminals shall be grouped together and segregated according to operating voltage and function by terminal rail mounted barriers. Stud type terminals shall be provided with individual segregating barriers.

7.5.10 Terminals shall face the compartment door for ease of connection.

7.5.11 Terminals shall be located and spaced so as to enable the easy disconnection and reconnection of conductors, whilst providing sufficient space for the looming and spreading of cable cores. Where practicable, the layout of terminal rails shall be such that cores from the same field cable are not split between non-adjacent groups of terminals.

7.5.12 All wiring of external connections shall be brought out to individual terminals on a readily accessible terminal block.

7.5.13 All spare contacts are to be wired back to terminals.

8. LOW VOLTAGE EARTHING

8.1 Main incoming earth terminal

8.1.1 The Assembly shall incorporate facilities for connecting to the main incoming earth terminal, subject to its location being clearly identified and easily and safely accessible with the Assembly energised. The Assembly earthing system may comprise either an earth bar extending the full length of the Assembly or, for Assemblies with less than or equal to two (2) functional units and a supply rating of less than 100 A, a stud arrangement.

8.1.2 Earth bars shall:

a) be manufactured from high conductivity copper (tinned for WWTW applications);

c) be located in a safe and easily accessible position;

d) have a minimum number of joints;

e) have at least one disconnecting link;

f) have facilities for connection to the main incoming earth terminal (the Supply Company earthing system and / or from a local earth electrode system) at each end of the bar, and

g) be rated and tested at a minimum of 60 % of the busbar fault withstand capacity

h) have a cross-sectional area of not be less than 500 mm^2, nor less than 50 mm in width.

i) be securely connected in each panel or cubicle to bare metal

8.1.3 Provision shall be made for the connection for the following connections to the fixed portion of the earth bar:

a) electrical installation main bonding conductors

j) functional earthing conductors external to the Assembly

k) equipotential bonding conductors external to the Assembly

l) other equipment protective conductors external to the Assembly

m) the Assembly main earth bar / circuit, which shall be terminated onto the fixed portion

n) an additional 2 No. spare terminations

8.1.4 All metallic non-current carrying parts of the Assembly shall be bonded together and connected to the Assembly earth busbar.

8.2 Compartment earthing

8.2.1 Each compartment shall include an earth stud connected to the main earth bar or stud by separate connections or by a common vertical earth tape. Earth conductors to each compartment shall be sized to withstand the fault level, subject to a minimum cross-sectional area of 6 mm^2.

8.2.2 The following shall be directly connected to the compartment earthing terminal by earthing conductors with a minimum cross sectional of 4 mm^2 or braided straps of similar rating:

a) compartment door

b) any removable cover

c) component / equipment mounting rails and earth terminals

8.2.3 A compartment may contain subsidiary earth terminals or bars to which the following circuits may be specifically connected:

a) ‘clean’ earths from instrumentation circuits and equipment

b) functional earths; e.g. from telecommunications equipment

c) surge protection earths; e.g. direct connections from lightning protection units

8.2.4 These earth terminals or bars shall be separately connected directly back to the Assembly main earth bar with 6 mm^2 minimum cross-section conductor.

8.2.5 Cable gland plates associated with a compartment shall be provided with an earth stud, which shall be connected directly to either the compartment earthing terminal, or to the main earth bar, with a conductor of 6 mm^2 minimum cross-sectional area.

8.2.6 Doors having components mounted on them shall be bonded to the main structure by means of flexible copper earth connection arranged so that it cannot be trapped as the door is opened or closed. Metal hinges shall not be considered sufficient to ensure electrical continuity.

8.2.7 Where cables carry low level high frequency signals, or are installed where there is a significant risk of high frequency interference; (e.g. in signal circuits connected to equipment containing power electronics), they shall where necessary have their screens / braids capacitively connected to earth in a proprietary manner, and proprietary means shall be included to provide 360° earthing for field cable braids / screens.

8.3 Intrinsically safe circuit earthing

8.3.1 If specified on the Project Specification, separate earth bars or studs shall be provided for connecting equipment requiring a clean earth or an intrinsically safe earth directly to the main incoming earth terminal. If required, such earth bars or studs shall be located adjacent to the equipment requiring a clean earth or an intrinsically safe earth, as appropriate.

8.3.2 Where zener diode safety barriers are contained within a compartment, they shall be separately and directly connected to the main earth bar via duplicate earthing conductors; each of 6 mm^2 minimum cross-section. These conductors shall be clearly identified as intrinsically safe earths.

9. POWER FACTOR CORRECTION

9.1 General requirements

9.1.1 Power factor correction capacitors shall be so selected and sized as to raise the lagging power factor due to induction motor loads; either individually or when summated across the Assembly, to a final corrected power factor of 0.97 lagging. When designing the system, the un-corrected power factor for each motor shall be taken as that quoted in manufacturers' literature for a high efficiency motor of equivalent rating operating continuously at its 75% duty point.

9.1.2 Capacitors shall be of the non-toxic self-healing dry metallised film type. Every capacitor or group of capacitors shall be provided with integral discharge resistors to reduce the residual terminal voltage to less than 50V within one minute of being disconnected from the supply.

9.1.3 Capacitors shall be suitable for continuous connection to a three phase low voltage industrial power supply. If the low voltage power system to which the Assembly will be connected has significant voltage waveform distortion or harmonic content, or has other capacitive or inductive networks (e.g. harmonic filters) connected to it, additional information must be obtained by the Contractor via site surveys.

9.2 Power factor correction for individual drives

9.2.1 Where power electronic soft starters are used, the sequence of the connection and de-energising of the capacitors shall be in accordance with the manufacturer's recommendations. Power factor correction shall not be applied to variable speed drive systems.

9.3 Bulk power factor correction

9.3.1 Where detailed in the Project Specification, bulk power factor correction shall be provided for the whole Assembly, in a purpose designed functional unit occupying one or more compartments within the enclosure.

9.3.2 Capacitors shall be arranged into banks, suitably sized to enable the incremental control of the power factor against a changing load. Each bank shall be automatically contactor controlled, in a manner that minimises switching surges, and capacitor bank status information shall be derived from the contactor auxiliary contacts. A proprietary multi-stage power factor controller, with a minimum of six steps, shall be used to monitor and sequence the switching of the capacitor banks.

9.3.3 Where there is provision to supply the Assembly from a generator, automatic means shall be included that will inhibit bulk power factor correction when the generator is in use.

10. POWER ELECTRONIC EQUIPMENT

10.1 Soft starting equipment

10.1.1 Soft starters shall comprise a proprietary item of chassis mounted equipment, designed for installation within an Assembly. They shall be rated to continuously carry the intended motor full load current, and provide the required number of starts per hour.

10.1.2 The soft starter shall be thermally designed to carry the motor current until the motor protection operates, and where this cannot be guaranteed, high speed semiconductor fuses shall be provided to protect the power electronics. Where such fuses are used, a spare set shall be provided and fixed within the compartment.

10.1.3 Soft starters shall be of a digital energy optimising design and shall incorporate appropriate motor protection, and where pumping circuits are being controlled, soft stop features shall be included. When the soft starter has completed the ramped application of motor voltage, a ‘top of ramp’ signal shall be generated.

10.1.4 Soft starters shall incorporate a built-in by-pass contactor rated for the full load running current of the motor, such that on receipt of the ‘top of ramp’ signal, the by-pass contactor shall close and divert the motor current away from the power electronics. When running in the by-passed condition, the motor shall continue to be provided with the full protection and monitoring features afforded by the motor starter. When a controlled stop command is received, the by-pass contactor shall be de-energised, in such a manner that the control of the motor is transferred to the power electronics.

10.1.5 Facilities shall be provided for the emergency stopping of the controlled motor in the shortest possible time. The emergency stop facility shall not be dependent on any software functions within the soft starter or its associated equipment and shall disconnect the soft starter from the supply by means of a full load rated line contactor fitted between the compartment isolation / protective device and the soft starter.

10.1.6 Where specified in the Project Specification, connectivity between the soft starter functional unit and other equipment or systems within the Assembly shall be via an open field device network compatible with the proposed PLC control system. It shall preferably use an interface device integrated within the soft starter, so as to provide remote network access to the full range of the soft starter’s control and monitoring facilities.

10.2 Variable speed drives (VSDs): General

10.2.1 The VSD motor starter shall comprise a variable frequency converter (VFC) , phase shift transformer(s) (where required), and all other components necessary to provide the full speed and torque control of an a.c. cage induction motor over the specified operating speed range up to the motor’s rated speed and full load current.

10.2.2 VFCs shall either be wall-mounted, housed within a motor control centre or free-standing units within their own enclosures as specified in the Project Specification.

10.2.3 Unless otherwise specified in the Project Specification, VFCs shall have uncontrolled rectifiers (i.e. diode front-end) with the specified pulse number (6/12/18). Either a.c. line reactors or d.c. link chokes shall be provided with all 6-pulse VFCs to reduce input current harmonics.

10.2.4 Where a phase shift transformer is required to achieve the specified rectifier pulse number, the transformer shall be provided as an integral component of the VSD and, unless otherwise specified in the Project Specification, shall be of the dry type and housed in a dedicated section of the VFC enclosure.

10.2.5 VFCs shall be capable of operating under the service conditions specified in Clause 4 of SANS 61800 Part2, and any unusual environmental service conditions specified in the Project Specification. Functional features and performance requirements shall be in accordance with Clauses 3 and 6 of SANS 61800 Part 2 respectively as varied

10.2.6 The output rating of the VFCs shall be selected to suit the associated motor and shall take into account the operating speed range.

10.2.7 Every VSD motor starter shall be provided with incoming supply isolation and short circuit protection as well as an input contactor if specified in the Project Specification.

10.2.8 The VSD shall provide the specified motor protection either as an integral part of the VFC or by way of a separate motor protection relay.

10.2.9 Where any semiconductor or special d.c. circuit fuses are used in the VFC power circuit, a spare set shall be provided . A list of all fuses, type, ordering code and supplier and supplier details shall also accompany the spare fuses.

10.2.10 The VSD control system shall incorporate comprehensive diagnostics to provide fault supervision and status indication in accordance with Clauses 3.2 and 3.3 respectively of SANS 61800 Part 2 and any additional requirements specified in the Project Specification.

10.2.11 Input/output devices and communication links shall be provided as specified in the Project Specification.

10.2.12 The Contractor shall ensure that the suppliers of the VFC and the associated motors confirm that their standard equipment is fully compatible and, if not, that the necessary equipment design changes (e.g. enhanced motor insulation) and/or supplementary equipment (output filters or reactors) is provided to ensure compatibility.

10.2.13 The Assembly shall permit adequate heat rejection from the VSD compartments and the Contractor shall provide estimates of the total heat rejection from the Assembly. The location of the Assembly and VSD panels, and the ventilation arrangement, shall be as specified in the Project Specification.

10.3 Variable Speed Drives (VSDs): EMC Requirements

10.3.1 All VSDS shall comply with the requirements of product standard SANS 61800-3 for Category C2/C3 as appropriate and an EMC filter shall be provided as part of a VFC if necessary to achieve the required electromagnetic compatibility.

10.3.2 The supply voltage distortion limits specified in the Project Specification shall be achieved through the use of diode front-end VFCs with higher pulse numbers, active front-end VFCs or harmonic filters. Documentary proof shall be provided with the Tender that the VFC input current harmonics will be limited to the required levels.

10.3.3 When specified in the Project Specification, the Contractor shall carry out a harmonic survey at the point of supply to measure background voltage harmonics. The Contractor shall repeat the survey after the commissioning of all VSDs to demonstrate that the actual harmonic performance of the VSDs under worst case operating conditions does not exceed the specified limits.

10.3.4 Any VFC input harmonic filters or line reactors and any output filters (i.e. dU/dT, common mode or sine filters) or reactors shall be provided as part of the VFC and shall be included in the supply price. Output filters shall be provided where required to ensure motor insulation compatibility and/or control of bearing currents. Output reactors shall be provided if motor supply cables exceed the allowable length.

10.3.5 The design of dedicated VFC input harmonic filters shall take account of the supply impedance provided in the Project Specification, any background voltage harmonics, any other reactances (e.g. transformers) or capacitors (e.g. power factor correction), or other filters connected to the power system, so as to avoid possible resonance problems.

10.4 Variable Speed Drives (VSDs): Control

10.4.1 The VSD control panel / operator interface shall be mounted in the face of the VSD panel/ Assembly. Control parameter adjustment shall be easily achievable by menu-driven option selections, with engineering options protected from unauthorised changes by the use of multi-level password protection.

10.4.2 All operator controls and indications shall be available front of panel, either via an operator interface / keypad, or by using discrete push-buttons and lamps, etc.

10.4.3 The VFC shall incorporate on-board protection, control and monitoring features, which shall include, as a minimum, the following:

a) On

b) Unit Ready

c) Overload

d) Failure

e) Current limit

f) Over voltage

g) Manual start and stop

h) Raise and lower speed

i) Current operating status

j) Speed indication

The VSD shall be such that when set in the 'manual' mode, operation from the control panel / operator interface shall be as follows:

a) a start command shall cause a normal ramped start up to the pre-set speed

b) a stop command shall cause a normal ramped down stop and shutdown of the drive

10.4.4 All diagnostic and fault messages shall be stored, whether reset or not and it shall be possible to recall them from the operator interface/control panel.

10.4.5 All VFC function parameters shall be programmable from a dedicated keypad, or via a standard programming software package installed on a standard portable notebook. A serial communications port to RS232 / RS485 standard or other network communication port shall be provided for dedicated communication with the VFC, and via which all programmable, control, monitoring and diagnostic functions available locally at the VFC shall be accessible.

10.4.6 A copy of the configuration /standard programming software shall be provided with each VSD.

11. CONTROL CIRCUIT SUPPLIES

11.1 Provision of control circuit supplies

11.1.1 Fixed pattern functional units shall incorporate individual control circuit supplies that are derived from within the functional unit.

11.1.2 Control circuit supplies shall be 230V AC (single pole and neutral) or 24V DC as specified in the Project Specification. They shall be separately derived from double wound transformers, which where practicable shall have 400V primary windings. Double pole primary winding protection shall be provided by fuses or a miniature circuit breaker.

11.1.3 The rating of each control transformer shall exceed the sum of the foreseeable maximum continuous load (which for an electromagnetic device shall be the ‘hold-in’ VA) plus the in-rush current of the largest or simultaneously operating load device(s) (e.g. the ‘pull-in’ VA).

11.1.4 Control circuit supplies shall comply with SANS 60204-1, and the neutral terminal of each transformer secondary winding shall be provided with a removable link, and shall be connected to earth. Secondary winding overcurrent protection shall be provided.

11.2 Control circuit features

11.2.1 One pole of every contactor and auxiliary relay coil, timer, etc. shall be connected directly to the neutral (i.e. earthed) side of the control supply. Each control circuit shall be sectionalised and arranged such that where practicable, discrimination is achieved under fault conditions.

11.2.2 Where possible, common controls and ICA compartment circuits shall operate at 24V DC, and shall interface with the functional unit 230V AC control circuits by means of 24V DC interposing relay(s) located in the functional units.

12. SIGNS AND LABELS

12.1 General

12.1.1 Safety signs and labels shall be provided wherever necessary in relevant languages so as to unambiguously communicate safety and functional guidance to any person who may operate the Assembly or otherwise come into contact with any part of the electrical system forming a part of the Assembly, and shall be provided for the specific identification of every component contained within the Assembly.

12.1.2 Signs and labels shall be located in such a manner that:

a) it is obvious as to the nature and location of the hazards or component(s) to which they relate

b) when mounted on any enclosure cover or plate, there is no possibility of that cover or plate being interchanged with any similar item on that Assembly or on any other Assembly supplied to the same site

c) they are not fixed to easily removable parts (e.g. trunking covers, etc.), unless their purpose is to warn of the consequences of removing a removable part

d) they are at all times adjacent to the item to which they refer, and accommodate situations where components could be moved along a DIN mounting rail

e) they will not be obscured by any equipment, components, or wiring, etc.

f) they are legible and will remain easily read throughout the life of the Assembly

g) Signs and labels shall be securely and permanently fixed using an appropriate number of corrosion resistant, mechanical fixings. The fixing of labels, safety signs and notices shall not affect the IP rating of the Assembly.

12.1.3 Short individually fixed labels covering several items only, shall be used in lieu of long multi-legend labels; e.g. above a row of indicator lamps.

12.1.4 Self-adhesive, vinyl safety signs may be used if there is no requirement for special legend and propriety safety signs are available.

12.1.5 Safety signs and labels shall be of such size that the legend thereon is clearly legible from the operating position (or a 3m distance), and the pictograph and its accompanying text shall be chosen so as to provide the appropriate communication in an explicit and unambiguous manner.

12.1.6 Safety signs and labels fixed to the outside of the enclosure shall be manufactured from 1.5mm thick anti-reflective polycarbonate with the legend reverse screen printed, or alternatively from 3mm thick bevel-edged clear perspex rear engraved with black characters. Internal labels may be manufactured from a laminated plastic material which shall normally provide a black legend against a white background. Where specifically agreed with the Engineer, internally mounted labels and charts, e.g. for distribution boards, etc., may be of permanently printed plastic, plastic laminated thin card, or thin card protected behind perspex.

12.2 Safety Signs

12.2.1 As a minimum, safety signs shall be fitted to removable covers over busbars and live connections, and to doors of compartments containing:

a) incoming supply cable termination points

b) internal switching and isolation devices

c) incoming or internal means of isolation; stating the highest voltage controlled by the means of isolation

d) functional units incorporating capacitors

e) more than one supply or multiple control circuits originating elsewhere

f) equipment located in a 'safe area' but associated with certified apparatus located in a hazardous area; a sign shall also be fitted at the safe area cable termination rail.

12.2.2 A safety sign identifying the operating voltage shall be placed in any compartment where there is equipment, components, or wiring, that can be energised at above extra low voltage.

12.2.3 Where there is no suitable standard symbol or pictograph, an application specific sign may be produced using simple and appropriate symbols, pictographs, and text, to indicate the hazard in a simple and straight forward manner that is acceptable to the Engineer.

12.2.4 Multipurpose signs shall be used where there is a need to communicate multiple hazard messages.

12.3 Labelling

12.3.1 The text of every label, excluding individual internal component identification labels, shall be as agreed with the Engineer.

12.3.2 Every Assembly shall be provided with a name plate detailing the following:

a) Manufacturer's name or trademark

b) Manufacturer's contact details

c) Manufacturer's type designation, serial / identification number

d) Date of manufacture

e) Rated operational voltages, frequencies, and number of phases

f) Continuous busbar rating

g) Short circuit withstand current and duration

h) IP rating

12.3.3 An application name shall be prominently displayed on the Assembly, as detailed in the Particular Specification.

12.3.4 Each compartment shall be identified with a designation label which shall include the full plant functional name and the alpha numeric reference cross referenced to as-built drawings and documentation contained in the Operation and Maintenance Manual. For rear access Assemblies, a duplicate designation label, mounted adjacent to the gland box, shall also be provided at the rear of each compartment.

12.3.5 The material used shall be selected having regard to the size and fixing methods of the label and the label shall not warp in service. Labels mounted on the outside of the Assembly shall rectangle in form and be manufactured of either:

a) Laminated plastic, engraved so as to produce black letters on a white background

b) Engraved sandwich board ("Trifoliate", "Darvic" or equal)

c) Reverse engraved acrylic material ("Perspex") with filled letters and reverse sprayed

12.3.6 For outdoor applications (where specified) labels shall be brass or aluminium (with letters filled in black), lightly sanded with fine grit paper and clear lacquered

12.3.7 Labels for door mounted components and labels used inside the Assembly shall be to the same standard or may alternatively be printed using an approved, propriety system.

12.3.8 Text characters shall be uniform in height, in upper case (except where standard abbreviations of units are used, e.g. kWh, kVA, etc.) and of the following minimum dimensions:

a) application labels: 8mm

b) compartment designation labels: 6mm

c) information or warning labels: 6mm

d) component identification labels: 3mm

12.3.9 All components shall be clearly labelled. Internal components shall be clearly identified by individual labels to indicate the equipment to which they relate. The component identification labels shall correlate with the Assembly drawings and documentation. If this is not practical due to space restrictions, common labels (e.g. diagrams may be used).

12.3.10 Current transformers shall be provided with separate and individual identification and rating plates.

12.3.11 Each distribution board shall be provided with a circuit chart laid out in a way that matches the orientation and layout of the protective devices in the distribution board.

12.3.12 A typed circuit chart shall be permanently fixed inside each Assembly or immediately adjacent to the distribution board. The chart shall be laid out in accordance with the physical arrangement of the protective devices that it is easy to relate the circuit chart details to the appropriate protective device. As a minimum, the chart shall be enclosed in a transparent protective cover attached to the inside of the compartment door.

13. INSTALLATION REQUIREMENTS

13.1 Shipping

13.1.1 Assemblies shall be shipped in sections to facilitate field handling for transportation and installation. The shipped sections shall be joined together to form a complete unit assembly.

13.1.2 Preparation for shipment shall protect the Assembly auxiliary devices accessories, etc. against corrosion, breakage or vibration injury during transportation and handling.

13.1.3 Disassembly shall be into the largest components or sub-assemblies possible, consistent with packing, road transport and handling limitations.

13.1.4 All parts shall be clearly and lastingly match marked to facilitate field erection prior to disassembly and packing for transport. Instructions shall be provided for reassembly of sections in the field or accompanied by a qualified representative from the Assembly Manufacturer.

13.1.5 The Contractor shall be responsible for delivery including loading and unloading of all equipment to site.

13.1.6 The Contractor shall provide information (in time) regarding specialised handling and storage requirements/techniques for equipment on the site until finally installed in the operating location.

14. LOCAL CONTROL PANELS

14.1 General requirements

14.1.1 The START/STOP pushbutton or control station shall be mounted adjacent to the drive.

14.1.2 The enclosure incorporating the pushbuttons, selector switches and indicating lights shall be fully water, weather and vermin-proof and shall have a minimum rating of IP65. The enclosure shall be manufactured from 3CR12 and shall be painted B26 to SANS 1091.

14.1.3 All pushbutton control station shall be pedestal mounted on a bracket at least 1 000 mm above ground/floor level.

14.1.4 All START pushbuttons shall be green and the operator shall be flush with the surrounding bezel.

14.1.5 All STOP pushbuttons shall be a red mushroom head latching push button and shall serve as an emergency stop.

14.1.6 All selector switches shall be rotary selector switches with black operators.

14.1.7 The control/pushbutton station shall be adequately designed to provide space for the following:

a) The required pushbuttons, selector switches and indicating lights complete with their appropriate labels.

b) Termination of all control wiring associated with the drive or group of drives. The minimum terminal strip length is 150 mm. A single multicore control cable shall be installed from the Assembly to the station, from where the required signals will be individually wired.

c) Stations for submersible equipment shall in addition of the required control cables, also provide for the termination of all the required power cables.

d) Sufficient space shall be provided for the glanding of the required cables.

14.1.8 All further requirements pertaining to the design, construction, installation and commissioning of control panels (e.g. Labelling, earthing, commissioning, etc.) shall be as specified in the relevant subsections of this Specification.

14.2 Start/Stop pushbutton stations

14.2.1 In addition to the above general requirements, START/STOP pushbutton station shall confirm to the following additional requirement:

a) One START pushbutton

b) One STOP pushbutton., The STOP pushbutton shall be twist to release.

c) Where reverse local control is required the reverse button shall not latch unless required.

15. FUNCTIONAL DESIGN

15.1 Specification to the Contractor

The Engineer shall provide the Contractor with the following information, which will form the basis for the design of the Assembly:

15.1.1 The Particular Specification

The Project Specification will detail all project specific requirements.

15.1.2 MCC and Local Control Table

The MCC and Local Control Table will be a schedule of all external connections and their function, ratings, etc. It gives an indication of each load's kW rating and the relevant circuit breaker size that must be selected. Also stated will be the type of starting, the local visual indication and the requirements for manual, automatic and local control needed.

15.1.3 I/O Schedule

The I/O Schedule will detail all the input and output signals (analogue and digital) for the controller connections, and the relevant equipment part it connects to.

15.1.4 Technical Data Sheets

The Technical Data Sheets are intended for use as standard templates, which will be completed and inserted into the Project Specification documents, so as to detail the project and product specific requirements for each Assembly as a whole, and for its constituent functional units.

Project specific configuration of the Technical Data Sheets will take the form of a 'YES' 'NO', insertion of a value or , together with the provision of an associated Particular Specification clause, cross-reference, or stated requirement, etc., as appropriate. When compiling a Project Specification document, only those Technical Data Sheets applicable to the required functional units will be included.

One set of Technical Data Sheets will be prepared per Assembly, unless therein detailed otherwise. Individual Technical Data Sheets may be duplicated if applicable, in order to accommodate the extent of scheme specific information.

15.1.5 Control Philosophy

The Control Philosophy will detail the functionality of all control and automation systems

15.1.6 Cable Block Diagram

The cable block diagram is a schematic that shows how the components of the Assembly is connected to the equipment and motors that it controls. It also indicates starting method, cable and circuit breaker sizes.

15.1.7 Assembly general arrangement drawing

A proposed layout shall be provided for the Contractor as indication of the relevant size constraints for the Assembly. It shall also indicate the number of functional units (e.g. motor starters, feeders, etc.) that is required for the Assembly.

15.1.8 Building arrangement drawing

A drawing indicating the Switchgear-room layout shall be used for functional considerations of the Assembly design. This drawing could be provided under the Civil part of the project.

16. TESTING AND COMMISSIONING

16.1 General requirements for testing

16.1.1 On completion of manufacture, the Assembly shall be subjected to a factory acceptance test (FAT), comprising the Manufacturer's in-house tests, and the repeat tests witnessed by the Client and the Engineer.

16.1.2 Once the witnessed FAT has been carried out, signed off, and any remedial works have been completed and re-tested, the Assembly is ready for delivery to site. Once erected in position, the Assembly shall be subjected to a witnessed site acceptance test (SAT).

16.1.3 Once the SAT has been carried out and signed off, any remedial works shall be completed and re-tested. Plant installation and site cabling will then be carried out by others, and on its completion, witnessed commissioning shall commence.

16.1.4 The manufacturer shall allow for each test (apart from in-house tests) to be witnessed by both the Client and the Engineers simultaneously. An individual testing activity shall not be considered to have been completed until any results have been recorded, and it has been signed off by the Engineer.

16.1.5 The manufacturer shall provide the Client and Engineers with all reasonable facilities, including testing staff and test equipment, to carry out the inspections and tests, and to check the Assembly for compliance with all of the Client's requirements.

16.1.6 The manufacturer shall ensure that all testing is carried out in a safe manner, and shall protect those witnessing from danger; in accordance with the Occupational Health and Safety Act.

16.1.7 In order to demonstrate the functionality of each circuit, external devices shall be simulated in a representative manner. A small motor shall be used as a test load where motor starters incorporate power electronics. During development, software may be electronically verified away from the Assembly using a simulation / diagnostic package; notwithstanding this, control systems shall be witnessed tested with the software loaded into the programmable devices, and with simulation of the physical I/O devices.

16.1.8 Where the Assembly incorporates equipment requiring special testing facilities or procedures, the manufacturer shall ensure that appropriate resources are available; including where necessary, representatives from the equipment Manufacturer.

PROCEDURE FOR TESTING AND COMMISSIONING

Action	Action By	Documentation
Design Assembly	Manufacturer/Contractor	
Check	Engineer	SLD drawings, Assembly GA drawings
Manufacturing	Manufacturer/Contractor	
In-house FAT	Manufacturer/Contractor	In-house FAT document
FAT	Manufacturer/Contractor/ Engineer/ Client (If required)	Final FAT document, Functional Specification
Delivery to Site	Manufacturer/Contractor	
SAT	Manufacturer/Contractor /Engineer	SAT document
O&M Manual & COC	Contractor to provide to Engineer	Draft Copy of O&M manual COC
Check	Engineer Contractor provides O&M Manuals	3 Copies of approved O&M manual
Final Test & Commissioning	Manufacturer/Contractor /Engineer/Client(If required	Commissioning Test document

FAT: ***Factory Acceptance Test;*** **O&M Manual:** ***Operating & Maintenance Manual;*** **SAT:** ***Site Acceptance Test;*** **COC:** ***Certificate of Compliance***

16.2 Factory acceptance tests (FATs)

16.2.1 The manufacturer shall perform his in-house works tests in accordance with the proposed FAT procedures, and shall satisfy himself as to the accuracy and quality of the manufactured Assembly in accordance with the accepted design. Once the in-house FAT has been carried out, signed off by the manufacturer, and any remedial works have been completed and re-tested, the tests shall be repeated and witnessed by the Client (if required) and the Engineer.

16.2.2 The in-house and the witnessed FATs shall check compliance with SANS 60439-1, and shall include the following:

a) A thorough external and internal visual inspection.

b) Confirmation of adequate earthing.

c) Secondary injection testing of all protective circuits shall be carried out, except where discrete current transformers are used; in which case sufficient primary injection testing shall be carried out to prove the ratio and the polarity.

d) Meggar tests shall be performed across all main and distribution busbar joints.

e) All busbars shall be subjected to a single witnessed reduced voltage dielectric 'flash' test; the in-house test shall also be at a reduced voltage.

f) All power circuits shall be subjected to insulation resistance tests.

g) The operation of every mechanical device and interlock shall be verified.

h) All circuits and their functionality shall be tested as detailed in the Control Philosophy and MCC and Local Control Table.

i) Any other test necessary to verify satisfaction with the requirements of Table 7 of SANS 60439-1.

16.2.3 When testing the performance of any software, it shall be demonstrated using the hardware intended to be incorporated within the Assembly, and where this is not possible appropriate operator interfaces, programming units, and terminal units, etc. shall be provided. Where it is necessary to demonstrate an interface with a piece of unavailable equipment to be supplied by others, appropriate means to replicate that equipment and simulate the interface shall be provided.

16.2.4 The Engineer preserves the right to cancel and postpone tests if he finds that the Contractor has not made reasonably sure that the test will be successful. Any extra costs incurred shall be borne by the Contractor.

16.3 Site acceptance test (SAT)

16.3.1 All equipment and every circuit that was altered or disturbed subsequent to the completion of the FAT, or for shipping and site erection, shall be specifically re-tested for integrity and functionality.

16.3.2 During the SAT, all busbar joints that are re-tightened on site shall be subjected to a further Meggar test, and all busbars shall be subjected to a single witnessed full voltage dielectric 'flash' test.

16.3.3 The process functionality of each aspect of the control system and its operator interface shall be demonstrated, including the correct operation of all I/O and network links external to the Assembly or not otherwise tested during the FAT.

16.3.4 A COC shall be provided to the Engineer, before final Testing and Commissioning can start.

16.4 Commissioning and other tests

16.4.1 The manufacturer shall provide attendance during the commissioning of the Assembly, whereby the functionality of the Assembly and its control system and software shall be proven. During commissioning the manufacturer shall make such adjustments, software modifications, and circuit changes, as are deemed necessary to provide the level of plant functionality and performance specified by the Client. All such changes shall be immediately incorporated into the 'as installed and tested' documentation and the Operating and Maintenance Manual, by the Contractor.

16.4.2 The manufacturer shall provide an acceptance document, to detail and record the tests and their anticipated results, and the acceptance document shall have provision for recording and signing off the results.

17. DOCUMENTATION AND TRAINING

17.1 General

17.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

a) the Client's name and contact details

b) Client's project / scheme / contract reference title and numbers

c) the Engineer's name and contact details

d) Engineers reference numbers

e) Contractor's works / contract / order references.

17.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

17.2 Drawings for Approval by the Engineer

17.2.1 The following documentation and drawings shall be submitted to the engineer prior to the procurement or manufacturing of Assemblies and related equipment:

a) Cable block diagrams.

b) General arrangement and elevation drawings, compartment door layouts, typical component mounting plate layouts, and foundation plans.

c) Electrical schematic diagrams showing all equipment and components incorporated into the Assembly. Known circuitry outside of the Assembly and connected to it, shall be shown on all drawings. Drawings shall be cross-referenced using a grid / line reference system.

d) Protective device grading for overcurrent, short circuit, and earth fault / leakage devices incorporated within the Assembly, together with a schedule of proposed settings that will ensure discrimination.

e) PLC software and configuration documentation; including ladder logic diagrams and HMI display screens, etc. The documentation shall be complete and annotated with purpose, function, duty, cross-references, and descriptions, etc.; sufficient to guide an unfamiliar person through the operation of the software.

17.3 Testing Documentation and Reports

17.3.1 The FAT and SAT shall be according to BS EN 62381.

17.3.2 A factory acceptance test (FAT) document shall be provided to the Engineer prior to the witnessed FAT. This documentation shall show the manufacturer's in-house test procedures and results for all items of equipment, components, hardware, and software. The document shall show hardware checks, the software simulation procedures, and their combined functional testing.. It shall comprehensively and clearly show the test results of the in-house testing. The subsequent report of the FAT witnessed by the Engineer shall be appended to this documentation.

17.3.3 The Contractor shall provide his own testing report template to document the FAT witnessed by the Engineer. This shall be to the satisfaction of the Engineer.

17.3.4 A site acceptance test (SAT) document shall be produced, which shall detail all tests necessary to demonstrate the functionality of the Assembly following its final erection on site. This shall include details of tests and checks on all circuits disconnected for shipping, together with any equipment, components, wiring, or software altered or incorporated into the Assembly; following the completion of the witnessed FATs.

17.3.5 All drawings, schedules, listings, and other design documentation for acceptance shall be supplied as a comprehensive and integrated package and collated into folders; unless otherwise agreed with the Engineer. Three copies of appropriate documentation shall be submitted on each occasion that agreement is sought.

17.3.6 A Certificate of Compliance (COC) shall be provided for all new Assemblies. For all refurbished Assemblies, a letter shall be provided listing all the repairs and stating that the Assemblies are still deemed to be reasonably safe.

17.3.7 The FAT, SAT, and COC shall each have been submitted and agreed with the Engineer, prior to the commencement of final testing and site commissioning.

17.4 Certificate of Compliance

17.4.1 A Certificate of Compliance (COC) shall be provided for all new Assemblies. For all refurbished Assemblies, a letter shall be provided listing all the repairs and stating that the Assemblies are still deemed to be safe.

17.4.2 The original COC shall go to the client's electrical representative.

17.4.3 A copy of the COC shall be included in the O&M Manual.

17.5 Operating and Maintenance Manual

17.5.1 One copy of the draft operating and maintenance manual and spare parts list shall be provided at an agreed date; in advance of the date of the start of the final testing and commissioning SATs, for acceptance by the Engineer. Three copies of the final editions shall be provided to the Engineer by an agreed date before successful completion of final testing and commissioning.

17.5.2 The Operating and Maintenance Manual shall be bound into a suite of hard-backed ring binders, and shall be provided with an index of all drawings pertinent to the Assembly. The index shall include each drawing's origin, number, issue, status, and the Client's drawing number (where issued by the Engineer).

17.5.3 The Operating and Maintenance Manual shall include the following:

a) All design drawings and documentation relating to the Assembly; as delivered and tested.

b) 'As installed and tested' records showing verification against stated design and installation criteria, including a schedule of all the final settings for all user adjustable equipment and components, and copies of all documentation presented and completed during the FATs, the SATs, and any other specified tests on completion.

c) Schedules of plant and equipment for each compartment / circuit; including a listing of the applicable standards, manufacturer, settings, type number, re-order code, etc., for each item of equipment and component included within the Assembly.

d) Manufacturers' contact details, technical information sheets for all items of equipment and components included within the Assembly. Manufacturers' catalogues may be provided subject to clear identification of the relevant components. All individual manufacturers' equipment / component test certificates and certificates of conformity, shall be included.

e) Inspection, testing, and maintenance recommendations, including detailed and specific operation, maintenance, and diagnostic data, and safe isolation information suitable for use by maintenance personnel, shall be provided for all equipment, components, and systems incorporated into the Assembly.

f) Schedule of spares provided with the Assembly, including manufacturer, description, part number, order code, and quantity.

17.5.4 The Operating and Maintenance Manual shall include detailed descriptions for use by the Client, on how the controlled plant and its management systems are intended to operate and be operated; under both manual and automatic control. Clear and detailed descriptions for each element of the Assembly shall be provided; and shall include system objectives, controlled plant start-up and shut-down procedures, automatic control, manual intervention, primary and secondary control routines, plant selection including duty and standby options, local and remote selections, operational and safety constraints, status information, alarms and control interfaces with control systems, fault routines, etc.

17.5.5 The Operating and Maintenance Manual shall include 'as-installed and tested' information on both the hardware and software for each programmable device incorporated within the Assembly, including:

a) Overview of system operation in relation to the controlled plant.

b) System configuration.

c) Manufacturers' literature on operation, maintenance and testing of hardware and ancillaries, programming instructions, and diagnostics.

d) Hard copy program; with listings fully documented.

e) Listing of the final settings of all process dependent variables.

f) Permanent back-up copies, licensed in the name of the Client, shall be provided for all software, including operating programmes, application programs, and configuration software for all configurable devices.

17.5.6 Any interconnecting leads, protocol conversion modules, connectors, etc. necessary to connect and communicate with each programmable / configurable device to a standard portable Notebook.

17.5.7 Manual format shall be A4 size on the filing side which shall be vertical with 20 mm margin for filing.

17.6 Training

17.6.1 General

a) The LV switchgear and Control Gear training shall form part of the overall training programme.

b) The Contractor shall conduct training courses for designated personnel in the maintenance and operation of the Assemblies.

c) The Assemblies shall be in a complete working order before training shall commence.

d) A training schedule, together with the name and background of the person who will perform the training, shall be submitted to the Engineer for approval.

e) Training and training manuals shall be based on the O&M Manuals.

f) Training manuals shall be delivered for each trainee with two additional copies delivered for archival at the project site. The manuals shall include an agenda, defined objectives for each course.

g) Where the Contractor presents portions of the course material by audio-visuals, copies of those audio-visuals shall be delivered to the Employer as part of the printed training manuals.

h) The Employer reserves the right to videotape the training sessions for later use.

i) The training shall include operator training and technical/maintenance training.

j) During the installation phase, a person will be designated by the Employer to be closely involved with the installation and commissioning process. The intention is not to interfere with the Contractors' installation team, but to do observation in order to obtain the maximum possible information regarding the installation, to enable efficient maintenance to be undertaken by the Employer after final hand-over and expiring of the guarantee period.

17.6.2 Operations& Maintenance training sessions

a) There shall be training sessions for the operation and maintenance of the Assemblies

b) The program for the training shall include instruction for at least one day per Assembly (8 hours) instruction on-site.

c) The program shall at a minimum cover the following:

i) General system overview

ii) Functional operation of the system i.e.:

- System start-up and shut-down procedures
- System access requirements
- Alarms
- Fault Finding
- Backup Power Procedure (if applicable)
- Incident Reporting

iii) Maintenance

- Maintenance Schedule
- Standard Maintenance Procedures
- Spare Part Lists

d) Upon completion of the course, the operators should be fully proficient in the system operation and have no unanswered questions regarding the system.

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1. SCOPE

1.1 Application

1.1.1 This document specifies the standard requirements for the supply, delivery to site, site installation, site testing, commissioning and handover of Low Voltage cable systems.

1.1.2 This document specifies the standard requirements for the design, installation, testing and commissioning of electrical installations operating on voltages up to 1 000 Volts AC / 1 500 Volts DC.

1.1.3 The primary intention of this specification is to ensure the provision of an electrical installation, which has been designed and constructed to ensure safe, reliable, operation and to facilitate safe inspection, testing and maintenance.

1.1.4 Note, however, that this specification only covers such installations (or sections of installations) that are covered by SANS 10142-1. Note also that certain provisions of this specification are inappropriate for direct application to installations where additional measures (such as earthing, intrinsic safe equipment, etc.) are required by SANS 10142-1 and SANS 10108 (i.e. medical and hazardous locations). For these types of installations, SANS 1411.

1.2 Electrical System Characteristics

1.2.1 The design of the installation shall comply with SANS 10142-1.

1.2.2 The design of the installation shall consider the following supply characteristics:

a) Voltage, frequency and number of phases

b) Maximum prospective short circuit current (phase to phase and phase to neutral)

c) Type of system, e.g. TN-S, TN-C-S

d) Maximum earth loop impedance of the earth fault path external to the installation

e) Type and rating of the cut-out or switch device

f) Load capability of the supply source, particularly the effects on the supply voltage of the starting of new equipment

1.2.3 The installation of protective devices shall be correctly co-ordinated within the installation and with respect to existing installations. Discrimination studies shall be performed to validate the co-ordination of the installation.

1.2.4 All equipment which requires operation or attendance by a person, or requires cleaning or maintenance in service, shall be constructed and installed to allow adequate and safe means of access and adequate working space for such activities.

1.2.5 Where additions or alterations to an existing installation are to be performed, the rating and condition of existing equipment, including that associated with the supply, shall be verified to confirm its suitability to carry any additional load. The earthing and equipotential bonding arrangements shall also be verified. No addition or alteration shall have an adverse effect on the existing installation.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Particular Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.

2.1.2 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.

2.1.3 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the installation.

2.2 Regulations, Specifications and Standards

2.2.1 The design, construction, inspection and testing of the installation shall comply with all relevant Statutory Regulations and Directives including:

a) Occupational Health and Safety Act (Act 85 of 1993)

b) Construction Regulations 2003 issued in terms of Section 43 of the Act

c) Local Fire Regulations; and

d) Regulations of the Local Supply Authority

and the latest editions (current at the time of Tender) of all relevant South African National Standards, as well as International Standards, including but not limited to:

Table 1 Reference Standards

Standard Number	Description
SANS 1213	Mechanical cable glands
SANS 1411	Materials of insulated electric cables and flexible cords
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SANS 10199	The design and installation of earth electrodes
SANS 10225	The design and construction of lighting masts
SANS 10142-1	Wiring of Premises Part 1: Low Voltage Installations
SANS 60614-2	Conduits for electrical installations - Particular specification for conduits
IEC 50086	Conduit systems for cable management

2.2.2 The installation shall also comply with:

a) This Specification, including all Technical Data Sheets; and

b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

3. GENERAL

3.1 General

3.1.1 Cables shall be manufactured strictly in accordance with SANS 1507.

3.1.2 Cables shall be delivered within 12 months of manufacture and shall be delivered to site on cable drums or coiled with protective wrappings.

3.1.3 Cables shall be delivered, stored and handled in accordance with the manufacturer's instructions. Where the performance of the cable is likely to be adversely affected by the ingress of moisture, it shall be adequately sealed at both ends

3.1.4 The end protruding from the drum shall be protected against mechanical damage.

3.1.5 Cable selection and sizing should comply with SANS 10142-1. Cables and their wireways shall, where required by SANS 10400 Part T to be protected against the effects of fire, be selected and installed in accordance with the provisions of such code.

3.1.6 Cables shall have copper or aluminium conductors according to SANS 1411-1. Cores of cross sectional area greater than 1,5 mm² shall be stranded or flexible.

3.1.7 Where neutral conductors are to be provided, they shall be of the same cross sectional area as the associated phase conductor, unless otherwise specified in the Particular Specification and drawings.

4. LOW VOLTAGE CABLES

4.1 Types of Low Voltage Cables

4.1.1 Unless otherwise specified, all LV cables shall have copper conductors to SANS 1411-1. Cores of cross sectional area greater than 1,5 mm^2 shall be stranded or flexible. Where neutral conductors are to be provided, they shall be of the same cross sectional area as the associated phase conductor, unless otherwise specified in the design documentation and drawings.

4.1.2 All LV cables used in an electrical installation shall be as specified in the Particular Specification (or cable schedule as part of the Particular Specification) and shall comply with either of the following:

a) PVC/AWA/PVC and PVC/SWA/PVC

- i) Cables shall comply with SANS 1507-3 and be rated at 600/1000 V.
- ii) Single core cables shall have aluminium wire armouring.
- iii) Multicore cables comprising five conductors and above shall have each core individually coloured, or, where not available, be coloured white with phase identification in black numerals.

b) XLPE/AWA/PVC and XLPE/SWA/PVC

- i) Cables shall comply with SANS 1507-4 and be rated at 600/1000 V.
- ii) Single core cables shall have aluminium wire armouring.

c) PVC/PVC

- i) Cables shall comply with SANS 1507-3 and be rated at 600/1000 V.

d) XLPE/PVC

- i) Cables shall comply with SANS 1507-4, and be rated at 600/100 V.

e) Single Core PVC

- i) Cables shall comply with SANS 1507-2 and be rated at 600/1000 V.
- ii) The insulation shall be phase coloured, and, where used in single phase systems, line cables shall be red, neutral cables black and earth cables yellow and green.

f) Flat Twin and Earth PVC

- i) Copper conductors shall comply with SANS 1411-1, PVC insulated to SANS 1411-2, laid up with a bare copper earth continuity conductor between them, with PVC bedding to SANS 1411-2.
- ii) Cables shall be rated at 300/500 V.

g) Fire Resistant Cables

- i) Cables requiring protection against the effects of fire shall be of fire-resistant construction (note here that “fire-rated” cables are not the same as “fire-resistant” cables).
- ii) Fire-resistant cables shall thus comply with SANS 60331-21 and / or BS EN 50200.

iii) Except where prior approval in this regard has been granted by the Engineer, increasing the resistance to fire of normal (i.e. non-fire resistant) cables though the application of a coat of fire-resistant compound will not be accepted.

4.2 Cable Accessories

4.2.1 Cable Markers

Concrete markers for the indication of cable or trench routes shall be placed at a minimum of 50 m intervals, changes in trench or cable direction and at road crossings. The markers shall protrude by 25 mm above finished ground level, except where they are likely to cause obstruction, when they shall be laid flush with the finished ground level.

5. INSTALLATION OF CABLES

5.1 General

5.1.1 The cable installation shall comply with the requirements of SANS 10142-1.

5.1.2 Cables shall be installed strictly in accordance with the cable route drawings.

5.1.3 Cables installed in groups shall run in straight lines and not cross over each other, except where transposing of cables is required to reduce capacitive or inductive effects.

5.1.4 Cables installed above ground shall, as far possible, run parallel with the lines of building construction. Cables and wireways shall then only be installed in horizontal and vertical runs, and the installation shall be as visually unobtrusive as possible.

5.1.5 Cables buried below ground shall, as far as possible, follow features of the site such as roadways and building lines.

5.1.6 Where a redundant cable installation is required, the cables shall not be installed along the same route, and their routes shall be through separate fire compartments (except where no separation occurs, as may be the case in the vicinity of the source and load).

5.1.7 Cables and their support systems shall not be fixed to protective barriers, guards or directly to guard-rails.

5.1.8 Cables shall not be exposed to direct sunlight after installation. If the cable route compels the support system to be in direct sunlight, the Contractor shall ensure cables are covered with a suitable canopy or cover of the same material as the support system (tray). Cables shall be installed strictly according to the manufacturer's requirements pertaining to:

a) Maximum tensile or compressive stresses (e.g. due to pinching or squashing)

b) Minimum bending radii

c) Temperature of installation; and

d) Operating environment

5.1.9 No joints or repairs to outer sheathings or insulation shall be allowed in low-voltage cables without the prior approval of the Engineer.

5.1.10 Propriety (i.e. suited to and manufactured for such use) cable support systems shall be used.

5.1.11 Unarmoured cables shall only be used where there is no risk of mechanical damage.

5.1.12 Fire resistant cables shall only be supported by fire resistant cable support systems.

5.1.13 After cable installation, the open end of all cable sleeves and the openings in building structures specifically provided for the passage of cables (including unused openings) shall be fire sealed to SANS 10177 Part 2, thus preventing the ingress of harmful or flammable gases, liquid, smoke, fire and vermin.

5.2 Separation of Cables

5.2.1 Cables shall be classified as follows:

Table 2 Cable Classification

	AC	DC
High Voltage	> 1000 Vrms	> 1500 V
Low voltage (power, control, small power and lighting)	50–1000 Vrms	120–1500 V
Extra-low voltage (signal/instrument, data transmission and telecommunication)	< 50 Vrms	< 120 V

5.2.2 Except for reasons of electromagnetic compatibility, where larger separation will be required, the minimum separation distance between cables of different classifications shall be according to the following table.

Table 3 Separation distance

Separation (mm)	Extra Low Voltage	Low Voltage	Other Services (Above Ground)	Other Services (Below Ground)
Extra Low Voltage	-	As specified	150	500
Low Voltage	As specified	2 x cables above ground 100mm below ground	150	500
High Voltage Cables	500	300	300	500
Other Services (Above Ground)	150	150	-	-
Other Services (Below Ground)	500	500	-	-
Note:				
1. The above figures need not to apply to the short lengths of cables near the equipment to which the cable are connected. 2. Clearances to power lines are excluded from above table as they are covered by the Electrical Machinery Regulations. Furthermore, clearances to traction lines are subject to the regulations of the relevant railway authorities.				

5.2.3 The figures specified in the table above do not apply to cables that are installed in separate metal enclosures and/or cables on cable support systems (cable trays/ladders) that are separated with conductive partitions, provided such partitions are electrically bonded to earth.

5.2.4 Notwithstanding above, cables of different classifications and/or purpose (e.g. data, audio or power), shall not be installed in the same duct or wireway, and the minimum separation distance shall be kept even when their ducts or wireways are bonded (since radio frequency interference may then still be exhibited).

5.2.5 When cables have to cross, the crossing shall be at right angles.

5.3 Cable Trenches in Ground

5.3.1 General

a) The proposed trench route shall be surveyed for the presence of underground cables and/or services before digging commences.

b) The site shall be preserved as far as possible. Only the minimum of trees, shrubs, rocks, etc. shall be removed and cleared for the cable route.

c) Where surplus material has to be disposed of, the Contractor shall remove it from site and dispose of it in a location of his choosing in accordance with statutory environmental regulations.

5.3.2 Excavation

a) The cable trench shall be excavated along the routes indicated on the relevant drawings.

b) Should the Contractor, during the excavation operations, come across obstacles (or other interferences, e.g. soil drenched with hydrocarbon-based solvents such as spilt oil, which could adversely affect cable insulation), the Contractor shall report the matter to the Engineer, who shall then advise an appropriate course of action.

c) Trenches shall be dug to within the dimensional tolerances given by SANS 1200, parts DB and LC.

d) Where the Contractor cannot excavate by means of machines, due to limited access and the proximity of other services, excavations shall be by hand.

e) The bottom of the trench shall be level and shall follow the contours of the final ground level. Where the excavation is in excess of the required depth, the excavation shall be backfilled and compacted with suitable material to the required depth.

f) The Contractor shall trim the trenches and clean up the bottom of the trenches after he has completed the required excavation.

g) The Contractor shall remove all sharp projections, which could damage the cable where the trench is excavated through rocky formations, and shall remove all loose rocks, material, etc. from the bottom of the trench.

h) No excavated material shall be left closer than 300 mm from the side of the excavation.

i) Once the excavations for cable trenches have been completed, the Contractor shall give the Engineer one working day notice to inspect the trench and to be present when the measurements are made.

j) The Contractor shall maintain the excavation in a good condition, free of water, mud, lose ground, rocks, stones, gravel and other strange material until the cables are installed.

5.3.3 Installation of Cables Directly in Ground

a) Dimensions of trenches for the installation of cables directly in ground

b) Trenches shall be excavated as follows:

Table 4 Excavation of trenches

	Width	Depth
Telecommunication Cable	450 mm	650 mm
LV Cable	450 mm	650 mm

c) However, the following minimum clearances shall be maintained:

Table 5 Minimum clearances

	Vertical	Horizontal
Data and Telecom Cables	300 mm	300 mm
Water pipes	300 mm	300 mm
Sewer pipes	300 mm	800 mm
Storm water pipes	300 mm	600 mm
LV cables on same route	100 mm	One cable diameter of larger cable

d) Where a cable will cross over other services, the cable shall not be installed at a depth less than 600 mm below ground level, and if this is not possible the cable shall be installed underneath the other service and shall be protected in the prescribed manner by means of concrete slabs. The depth of the cable shall be maintained for one metre on either side of the crossing.

e) If it is not possible to cross over or underneath a service in the prescribed manner, the matter shall be referred to the Engineer for a decision.

f) Where more than one cable need to be installed in a trench, the width of the trench shall be increased with a distance equal to the clearance required.

5.3.4 Sand bed and sand bed cover for cables

a) A sand bed layer of soft soil shall be installed and levelled at the bottom of each trench after the trench has been approved by the Engineer, and prior to cable laying.

b) If the excavated material is not suitable for the sand bed layer, then suitable soil shall be imported for this purpose. Quarried sand, man-made sand, sand clay and loam is usually suitable; sea sand, river sand, clay, chalk, unmixed ouklip, peat and mine sand may not be used. The cost of importing shall be included in the price for the excavation.

c) The minimum thickness of the sand bed layer shall be 50 mm.

d) If the soil for the sand bed and sand cover has to be sifted, a sieve with holes not larger than 6 mm shall be used.

e) The cable shall, after the completion of the trench, be laid as soon as possible so that the trench can be backfilled.

f) The sand bed cover for LV cables shall be 150 mm thick, of similar soil and shall be placed directly after the cable(s) has been inspected by the Engineer.

g) Only one cable shall be laid at a time and the Contractor shall take precautions that the cables which are already installed are not damaged.

5.3.5 Laying of cables

a) Cable rollers shall be used when cables are drawn into trenches. The cable rollers shall be placed so that the cable does not touch the bottom or the sides of the trench.

b) If the Contractor intends using a winch to draw the cable into the trench, a cable stocking shall be used or the draw wires shall be soldered to the cable, such that the tension is exerted on all the cores, lead sheath and/or steel wire armouring at the same time.

c) The maximum tension on a cable during laying operations shall not exceed the value specified by the manufacturer.

d) Sufficient lengths of cable shall be left at the beginning and end of the cable routes to allow for the termination of the cables. The Contractor shall take the necessary precautions to protect the cable ends until they are terminated. The cable ends shall be sealed by means of lead or heatshrink sealing caps to ensure that the cable is waterproof.

e) Where cables are drawn through sleeves, care shall be taken that they are not kinked or excessively bent.

f) The Contractor shall keep accurate records of each length of cable laid. The following information shall be recorded:

i) Cable drum number

ii) Size of cable

iii) Where the cable has been laid, i.e. the starting and finishing points

iv) Length of cable

v) Date laid

g) The Contractor shall be liable for the repair of cables due to the faulty manufacture, should this information not be recorded directly after the cable has been laid.

h) The Engineer shall inspect all cable trenches before backfilling to ensure that the laying of cables complies with the specification.

5.3.6 Backfilling of trenches

a) When the cable has been laid, inspected and approved and the sand bed cover has been installed, the trench shall be backfilled with soil containing not more than 40 % rock or shale which shall be able to pass through a 100 mm sieve and which is approved by the Engineer.

b) Where more than 40 %, but less than 70 %, rock occurs, the Contractor shall replace the rock with imported soil. However, should more than 70% rock occur then all the backfilling material shall be imported.

c) The Contractor may import further stone-free material to the site or sieve the excavated material for sand bedding and cover but payment shall only be compensated for the actual quantity of imported material required as determined by the Engineer. The quantity of imported material required shall be calculated from the nominal trench width.

d) The excavated material shall be backfilled in layers of 150 mm and shall be well compacted and consolidated to 90 % MOD AASHTO. Where the Engineer deems necessary, the Contractor shall use a mechanical vibrator to compact the trench.

e) The Contractor shall maintain the completed sections of the cable trench in a proper safe condition for the duration of the contract. The Contractor shall refill and compact the trench where subsidence occurs.

f) After completion of the work the route of the cable shall be neatly finished off and cleared. All stones bigger than 25 mm, as well as all loose organic material and rubble, shall be removed.

g) Electrical warning tape, consisting of two tapes laid side-by-side and overlapping (such that their combined width is 150 % of a single tape width), shall be installed on all cable routes (LV and MV), 200 mm above the top cable layer. Where a cable route exceeds 600 mm in width, multiple warning tapes shall be run, in such a way that the space between adjacent warning tapes does not exceed 150 mm.

5.3.7 Installation of concrete slabs

Where cables cross other services such as water pipes, sewage pipes and other cables, or where the chance exists that the cable may be damaged as a result of excavation by others, the cable shall be protected by means of reinforced concrete slabs. The slabs shall protect the cable for a distance of 500 mm on either side of the crossing.

5.4 Cable Sleeves

5.4.1 General

a) The construction of sleeves, draw pits and associated earthworks shall be in accordance with SANS 2001-DP3.

b) Sleeves shall be PVC unless otherwise specified.

c) The sleeves shall have a minimum wall thickness of 5 mm and mass not exceeding 45 kg per sleeve length.

d) Where a change of direction is required, draw pits shall be constructed. Bends may only be used where prior approval has been granted by the Engineer. Where such approval has been granted, the maximum angle of a single bend in a sleeve shall be:

i) 45º, when all cables have a diameter less than 35 mm; or

ii) 22.5º, where any cable has a diameter greater than 35 mm.

e) All bends shall be of the long radius type.

5.4.2 Method of Laying

a) In order to facilitate future location of the sleeves, they are to be installed strictly in accordance with the relevant drawings.

b) The Contractor shall select the number and/or dimensions of sleeves such that an additional cable, of outside diameter equal to 20 % of the sum of the outside diameters of the installed cables, can be pulled into the sleeve at a future date. Under roadways, this spare capacity shall be 50 %. Notwithstanding above requirement, a minimum of two sleeves shall be installed under all roadway crossings.

c) When installed beneath roads, there shall be a minimum of 750 mm of cover above the crown of the sleeve, and the sleeve shall be extended to 1,5 m on either side of the road surface or kerb face.

d) Where sleeves are installed during road construction, the sleeve positions shall be marked with the letters "E" or “ESC” for electrical, and “TEL” for telecommunication sleeves, cut or cast into the concrete of the kerb (or concrete marker, should the road be without kerbs). The grooved letters shall also be painted red, to facilitate easy identification.

e) The sleeves shall be laid straight to within the dimensional tolerances given by SANS 1200 part LC.

f) After installation, all foreign matter in the pipe shall be cleared.

g) The sleeves shall be sealed with PVC plugs to prevent the entry of sand before backfilling.

h) Precautions shall be taken to prevent damage to the sleeves during future construction activities.

i) All sleeves shall be left with an 8 mm diameter nylon draw wire, or draw wire to SANS 2001-DP3, in place, anchored at each end.

5.4.3 Bore and Sleeve Jointing

a) The bore shall be accurate, smooth and without surface cracks, and the inside edges edged or rounded.

b) The edging or rounding shall be such that no ridge is formed when two sleeves are joined.

c) A suitable slip collar, or other simple device, shall be provided to maintain the 5 mm spacing after the installation of the sleeves.

d) Joints shall be carried out with suitable couplings to prevent movement between pipe ends.

e) Joints shall be flexible enough to allow angular adjustments of up to 5º between adjacent lengths of sleeves during installation and afterwards to allow for subsequent subsidence of the ground.

f) The joints need not be watertight, but shall stop sand and other materials entering the sleeves.

5.4.4 Draw pits and masonry

a) Where they are to be constructed in residential or commercial zoned areas, and where part of the draw pit will be visible above ground, the masonry units to draw pits shall be FBS (face brick standard). All other draw pit builds shall utilize solid concrete units.

b) Draw pits covers shall be of cast iron manufacture, or as specified in the particular specification.

6. MARKING AND LABELLING OF CABLES

6.1 Low Voltage Cables

6.1.1 Conductors and/or cables shall be identified at both ends by cable markers, consisting of plastic sleeves with pre-printed, legible and indelible alpha/numeric element inserts. The plastic sleeves shall fully encircle the conductor and/or cable. The markers shall be suitable for the intended environment, for instance, UV resistant where installed in sunlight, etc. Reference character sizes shall not be less than 3 mm high.

6.1.2 The colours of conductor PVC insulation shall comply with SANS 10142-1, par. 6.3.3. The colours of conductors for sub-circuits shall as far as possible correspond with the colour of the supply phase. Except in the case of multi-way switching, the colour of a conductor may not change at any point along its run, starting from its point of origin at a circuit breaker inside the switchgear assembly. In other words, where loop wiring is employed, the colour of conductor insulation shall be the same throughout the circuit.

7. DRAWINGS AND DOCUMENTATION

7.1 General

7.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

a) The Client's name and contact details

b) Client's project / scheme / contract reference title and numbers

c) The Engineer's name and contact details

d) Engineers reference numbers

e) Contractor's work / contract / order references

7.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

7.2 Drawings for Approval

7.2.1 The following documentation and drawings shall be submitted to the Engineer prior to the installation of cables and wireways and before civil construction have started on the areas where cable routes are required:

a) Cable route layout drawings showing

b) Type of wireways

c) Trenching

d) Cable junction boxes

7.3 As-built Drawings

7.3.1 The Contractor shall produce detailed "as-built" drawings, clearly labelled as such, and consisting of 3 sets of drawings printed to their original size. Where the original drawings were larger than A3, 3 sets of printed drawings scaled to A3 size will be supplied. The A3 drawings will not have any information omitted from the printed area. The drawings will indicate the positions of the following:

a) Wireways (e.g. trenches, conduit, cables ladder/trays, power skirting etc.);

b) Cable routes (including any cable joints)

c) General arrangement drawings

d) Single Line Diagrams

7.4 Operating and Maintenance Manual

7.4.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied. The manuals shall be in A4 format.

7.4.2 The operating and maintenance manuals shall include at least the following:

a) A schedule of installed components and equipment, containing the following information:

i) Manufacturers name and contact details

ii) Circuit number (DB name, circuit breaker e.g. DB01-CB08); and

iii) Function (e.g. switching lighting circuit DB03-L1)

b) A schedule of all installed cables, with the following information:

i) Circuit number (DB name, circuit breaker e.g. DB01-CB08)

ii) Size

iii) Installed length; and

iv) Function (e.g. "Feeding Submersible pump IW-SP-01")

c) Description and details of:

i) Detailed description of the function of all operator controls

ii) Procedures for fault finding

iii) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures

iv) Inspection schedules; and

v) Spare parts information and recommended spares

8. TESTING AND COMMISSIONING

8.1 General

8.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.

8.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.

8.1.3 The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall comply with SANS 61010 and have an up-to-date test and calibration certificate.

8.1.4 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.

8.1.5 Unless otherwise specified in the Particular Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10142-1.

8.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Particular Specification, the period of notice for witness testing shall be 5 working days.

8.1.7 Where most of the inspection and testing activities are not witnessed, the Contractor shall allow for 10 % of the inspection and testing activities to be repeated for witness testing.

8.1.8 If there is a requirement for additional inspection and test activities to be performed as part of the commissioning process, this shall be specified in the Particular Specification.

8.1.9 Unless otherwise agreed by the Employer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

8.2 Test Sequence

8.2.1 Inspections before testing:

Before testing, inspections shall be performed to verify:

a) All equipment and material is of the correct type and complies with applicable SANS and IEC standards

b) All parts of the installation are correctly selected and erected

c) No part of the installation is visibly damaged or otherwise defective

d) The installation is suitable for the environmental conditions; and

e) The installation complies with this Specification

8.2.2 Testing of Installation

On satisfactory completion of the inspections specified in 8.2.1 the following tests shall be undertaken in the sequence listed as per SANS 10142-1:

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Cable Support Systems

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Contents

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1. SCOPE

1.1 Application

1.1.1 This document specifies the standard requirements for the design, installation, testing and commissioning of electrical installations operating on voltages up to 1 000 Volts AC / 1 500 Volts DC.

1.1.2 The primary intention of this specification is to ensure the provision of an electrical installation, which has been designed and constructed to ensure safe, reliable, operation and to facilitate safe inspection, testing and maintenance.

1.1.3 Note, however, that this specification only covers such installations (or sections of installations) that are covered by SANS 10142-1. Note also that certain provisions of this specification are inappropriate for direct application to installations where additional measures (such as earthing, intrinsic safe equipment, etc.) are required by SANS 10142-1 and SANS 10108 (i.e. medical and hazardous locations). For these types of installations, thorough reference must be made to the relevant statutory documentation.

1.2 Electrical System Characteristics

1.2.1 The design of the installation shall comply with SANS 10142-1.

1.2.2 The design of the installation shall consider the following supply characteristics:

a) Voltage, frequency and number of phases
b) Maximum prospective short circuit current (phase to phase and phase to neutral)
c) Type of system, e.g. TN-S, TN-C-S
d) Maximum earth loop impedance of the earth fault path external to the installation
e) Type and rating of the cut-out or switch device
f) Load capability of the supply source, particularly the effects on the supply voltage of the starting of new equipment and any fault contributions from new equipment

1.2.3 The installation of protective devices shall be correctly co-ordinated within the installation and with respect to existing installations. Discrimination studies shall be performed to validate the co-ordination of the installation.

1.2.4 All equipment which requires operation or attendance by a person, or requires cleaning or maintenance in service, shall be constructed and installed to allow adequate and safe means of access and adequate working space for such activities. Similarly, the positioning of equipment shall not impede access to, or working space at, non-electrical equipment and services for operation and maintenance activities.

1.2.5 The installation shall be suitable for access and use by electrically unskilled persons.

1.2.6 Where additions or alterations to an existing installation are to be performed, the rating and condition of existing equipment, including that associated with the supply, shall be verified to confirm its suitability to carry any additional load. The earthing and equipotential bonding arrangements shall also be verified. No addition or alteration shall have an adverse effect on the existing installation.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Particular Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.

2.1.2 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.

2.1.3 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the installation.

2.2 Regulations, Specifications and Standards

2.2.1 The design, construction, inspection and testing of the installation shall comply with all relevant Statutory Regulations and Directives including:

a) Occupational Health and Safety Act (Act 85 of 1993)

b) Construction Regulations 2003 issued in terms of Section 43 of the Act

c) Local Fire Regulations; and

d) Regulations of the Local Supply Authority

and the latest editions (current at the time of Tender) of all relevant South African National Standards, as well as International Standards, including but not limited to:

Table 1: Reference Standards

Standard Number	Description
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
SANS 156	Moulded-case circuit-breakers
SANS 164	Two-pole and earthing-pin plugs and socket outlets
SANS 475	Luminaires for interior lighting, streetlighting and floodlighting - Performance requirements
SANS 767	Earth leakage protection unit
SANS 950	Unplasticized polyvinyl chloride rigid conduit and fittings for use in electrical installations
SANS 1063	Earth rods, couplers and connections
SANS 1085	Wall outlet boxes for the enclosure of electrical accessories
SANS 1088	Luminaire entries and spigots
SANS 1091	National colour standards of Paint
SANS 1195	Busbars
SANS 1213	Mechanical cable glands
SANS 1239	Plugs, socket-outlets and couplers for industrial purposes
SANS 1266	Ballasts for discharge lamps (excluding tubular fluorescent lamps)
SANS 1411	Materials of insulated electric cables and flexible cords
SANS 1431	Weldable structural steels

Standard Number	Description
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SANS 1700	Fasteners
SANS 1777	Photoelectric control units for lighting
SANS 1783	Sawn softwood timber
SANS 1973	Low-voltage switchgear and controlgear Assemblies
SANS 10155	Accuracy in buildings
SANS 10199	The design and installation of earth electrodes
SANS 10225	The design and construction of lighting masts
SANS 10177	Fire testing of materials, components and elements used in buildings Part 2: Fire resistance test for building elements
SANS 10142-1	Wiring of Premises Part 1: Low Voltage Installations
SANS 10400	The application of the National Building Regulations
SANS 60269	Low-voltage fuses
SANS 60309	Plugs, socket-outlets and couplers for industrial purposes
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 60614-2	Conduits for electrical installations - Particular specification for conduits
SANS 60669	Switches for household and similar fixed-electrical installations
SANS 60947	Low-voltage switchgear and controlgear
SANS 61000	Electromagnetic compatibility (EMC)
SANS 61010	Safety requirements for electrical equipment for measurement, control, and laboratory use
SANS 61048	Auxiliaries for lamps - Capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements
SANS 61238	Compression and mechanical connectors for power cables for rated voltages up to 30 kV(Um = 36 kV)
SANS 61643	Low-voltage surge protective devices
Other Standards	**Description**
ARP 035	Guidelines for the installation and maintenance of street lighting
BS 88	Specification of supplementary requirements for fuses of compact dimensions for use in 240 / 415 V industrial and commercial electric installations
IEC 157	Low voltage switchgear and control gear
IEC 408	Low voltage air-break switches, air-break disconnectors, air-break switch disconnectors and fuse combination units
IEC 12373	Aluminium and aluminium alloys. Anodizing. Method for specifying decorative and protective anodic oxidation coatings on aluminium
IEC 50086	Conduit systems for cable management
IEC 60898	Specification for circuit-breakers for overcurrent protection for household and similar installations

2.2.2 Standards are often tailored to the conditions of their country or origin (in terms of permissible voltages, expected ambient temperatures, etc.). Therefore, and unless normatively referenced to the contrary in a Standard of higher precedence, the decreasing order of precedence of Standards shall be:

a) South African National Standards (SANS, VC, etc.)

b) South African Sectoral Standards and Specifications (NERSA, CKS, ARP, NRS, PIESA, etc.)

c) ISO Standards

d) IEC Standards

e) Harmonized British Standards (BS EN)

f) Other Harmonized European National (EN) Standards (CEN, CENELEC, ETSI)

g) Non-Harmonized British Standards (BS)

h) Other international standards

2.2.3 Where Standards of the same order are not in agreement with each other, the Standard with the most rigorous requirements shall apply.

2.2.4 The installation shall also comply with:

a) This Specification, including all Technical Data Sheets; and

b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

3. INSTALLATION OF CABLE SUPPORTS

3.1 Cable Trays, Mesh and Ladders

3.1.1 General

a) Cable management systems (cable trays, cable ladders and cable mesh) shall be selected and installed strictly in accordance with their manufacturer's guidelines, with a safety factor of 1.5 after taking into account maximum permissible loading and all external factors (not limited to wind, snow and thermal expansion). Upon demand to do so, the Contractor must furnish all data and calculations he used to derive the type and spans of the systems to the Engineer.

b) Notwithstanding above, the deflection of a cable management system due to installed cable weights shall be, in accordance with IEC 61537, limited to 1/100th of the span.

c) Except where it is to be installed in locations with corrosive atmospheres, cable management systems shall be manufactured of galvanized and/or epoxy-powder coated steel. In locations with corrosive atmospheres, systems shall be manufactured from stainless steel (316 Marine Grade) or aluminium.

d) All clamps, clips, hinges screws, bolts, nuts and support fittings used for fastening cable trays or cables shall be of the same material as the cable management system itself.

e) Over and above the requirements of SANS 10142-1, all cable tray and ladder systems that will support telecommunication and / or control wiring shall be bonded in accordance with NRS 083-2 (gives details of bonding methods that provide enhanced protection against the effects of electromagnetic cross-interference).

f) Cable management systems shall be selected and installed such that spare capacity (weight as well as height and width) of 20 % will be available for the addition of future services (the cable management system to still exhibit a 1.5 safety factor after services were added).

3.1.2 Cable Trays

a) All cable trays shall be of the heavy duty, increased upstand ("siderail"), type.

b) Metal cable trays shall be manufactured from base-perforated (in excess of 30 % of the surface area, in accordance with SANS 10142-1, in other words, class D according to Table 4 of IEC 61537) rolled steel. Metal trays manufactured to the following standards shall be used:

   i) Less than 150 mm wide: 1,2 mm minimum thickness with 12 mm minimum upstand

   ii) 150 mm to 450 mm: 1,2 mm minimum thickness with 19 mm minimum upstand

   iii) Above 450 mm (heavy duty): 2,5 mm minimum thickness with 76 mm upstand

c) The edges of cable trays are to be turned up on both sides to improve rigidity (return flange cable tray), and, where necessary, the sides of trays shall be reinforced with galvanised steel angles, minimum 25 x 25 x 3 mm, with 25 x 3 mm cross-braces at 600 mm centres.

d) Cable trays shall be hot-dip galvanised only after the perforation and bending processes have been completed.

3.1.3 Cable Ladders

a) Metal cable ladders shall have side rails with 2 mm minimum thickness. Cross rungs shall be spaced at maximum intervals of 300 mm (measured between the centres of rungs). Where cables of 10 mm² or smaller are installed on cable ladders, the spacing of cross rungs shall be reduced to 125 mm.

b) Cable ladders consisting of slotted metal rails which accommodate plastic or metal cable binding bands may be used in vertical cable runs against walls, etc. These cable ladders will be considered in horizontal cable runs for small cables for communication and control wiring only after approval by the Engineer.

3.1.4 Cable Tray and Ladder Connections

a) Cable tray and ladder connections shall be suited to and of the same manufacture as the linear sections that they connect.

b) The dimensions of these connections shall correspond to the dimensions of the linear sections to which they are connected.

c) The radius of all bends shall be 1 m minimum. The inside dimensions of horizontal angles or connections shall be large enough to ensure that the allowable bending radii of cables are not exceeded.

d) Sharp angles shall be 45° mitred.

3.1.5 Installation of Cable Trays, Cable Ladders and Cable Mesh

a) The spacing between tiers of ladders, trays and/or mesh shall be 300 mm minimum. Furthermore, they shall be installed such that a minimum separation of 300 mm exists between ceilings and the top of a tray or ladder (where the latter is installed horizontally) and 50 mm between the nearest sides of trays or ladders and the finished surfaces of walls, floors and ceilings for other configurations.

b) Fixing materials shall be compatible with cable management system materials, and offer resistance to corrosion.

c) Cuts in trays shall not pass through perforations, except where practically impossible to implement.

d) Cable trays and mesh shall be mounted with a minimum air gap of 25 mm between the underside of the tray and the mounting surface.

3.1.6 Installation of Cables on Cable Trays, Ladders and Mesh

a) Cables shall be supported to avoid damage during installation, prior to dressing and fixing.

b) Depending on the overall diameter, single cables and groups shall be secured according to the following.

Table 2: Installation of cables

	Overall Diameter
Nylon UV Protected Cable Ties	< 35 mm
Propriety cable clamps	> 35 mm

c) In outdoor applications, where the installation maybe subject to ultra-violet light, PVC covered aluminium tape shall be used instead of nylon cable ties.

d) Cables installed in groups shall be installed in straight lines and not cross over each other, except where single core cables need to be transposed.

e) Where cables exit ladders, trays or mesh, the latter shall be formed or covered with PVC to ensure a smooth surface.

f) Where single core cables are installed in trefoil formation, trefoil cable clamps shall be used.

4. DRAWINGS AND DOCUMENTATION

4.1 General

4.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

a) The Client's name and contact details
b) Client's project / scheme / contract reference title and numbers
c) The Engineer's name and contact details
d) Engineers reference numbers
e) Contractor's works / contract / order references.

4.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

4.2 Drawings for Approval

4.2.1 The following documentation and drawings shall be submitted to the Engineer prior to the installation of cables and wireways and before civil construction have started on the areas where cable routes are required:

a) Cable route layout drawings showing
b) Type of wireways
c) Trenching
d) Cable junction boxes

4.3 As-built Drawings

4.3.1 Detailed "as-built" drawings, clearly labelled as such, and consisting of 3 sets of drawings printed to their original size, and, where the original drawings were larger than A3, 3 sets of drawings printed (with reduced scaling, but without omitting any information from the printed area), to A3, shall be provided by the Contractor, indicating positions of the following:

a) Wireways (e.g. trenches, conduit, cables ladder/trays, power skirting etc.); and
b) Cable routes (including any cable joints)
c) General arrangement drawings
d) Single Line Diagrams

4.4 Operating and Maintenance Manual

4.4.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied. The manuals shall be in A4 format.

4.4.2 The operating and maintenance manuals shall include at least the following:

a) A schedule of installed components and equipment, containing the following information:

   i) Manufacturers name and contact details

   ii) Circuit number (DB name, circuit breaker e.g. DB01-CB08); and

   iii) Function (e.g. switching lighting circuit DB03-L1)

b) A schedule of all installed cables, with the following information:

   i) Circuit number (DB name, circuit breaker e.g. DB01-CB08)

   ii) Size

iii) Installed length; and

iv) Function (e.g. "Feeding Submersible pump IW-SP-01")

c) Description and details w.r.t:

i) Detailed description of the function of all operator controls

ii) Procedures for fault finding

iii) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures

iv) Inspection schedules; and

v) Spare part information and recommended spares

5. TESTING AND COMMISSIONING

5.1 General

5.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.

5.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.

5.1.3 The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall comply with SANS 61010 and be covered by a current test and calibration certificate.

5.1.4 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.

5.1.5 Unless otherwise specified in the Particular Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10142-1.

5.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Particular Specification, the period of notice for witness testing shall be 5 working days.

5.1.7 Where most of the inspection and testing activities are not witnessed, the Contractor shall allow for 10 % of the inspection and testing activities to be repeated for witness testing.

5.1.8 If there is a requirement for additional inspection and test activities to be performed as part of process commissioning, this shall be specified in the Particular Specification.

5.1.9 Unless otherwise agreed by the Employer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

5.2 Test Sequence

5.2.1 Inspections before Testing

Before testing, inspections shall be performed to verify:

a) All equipment and material is of the correct type and complies with applicable SANS and IEC standards
b) All parts of the installation are correctly selected and erected
c) No part of the installation is visibly damaged or otherwise defective
d) The installation is suitable for the environmental conditions; and
e) The installation complies with this Specification

5.2.2 Testing of Installation

On satisfactory completion of the inspections specified in 5.2.1, the following tests shall be undertaken in the sequence listed as per SANS 10142-1:

a) Continuity of conductors
b) Resistance of Earthing conductor

c) Continuity of ring circuits Earth fault loop impedance at main switch
d) Elevated voltage on supply neutral Earth Resistance
e) Insulation resistance
f) Voltage, main distribution board - no load
g) Voltage, main distribution board - on load
h) Voltage at available load
i) Operation of earth leakage units
j) Earth leakage test button
k) Polarity at points of consumption
l) Switching devices

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aurecon

Engineering Standard

Wiring and Outlets

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Contents

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1. SCOPE

1.1 Application

1.1.1 This document specifies the standard requirements for the design, installation, testing and commissioning of electrical installations operating on voltages up to 1 000 Volts AC / 1 500 Volts DC.

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e) Type and rating of the cut-out or switch device

f) Load capability of the supply source, particularly the effects on the supply voltage of the starting of new equipment and any fault contributions from new equipment

1.2.3 The installation protective devices shall be correctly co-ordinated within the installation and with respect to existing installations. Discrimination studies shall be performed to validate the co-ordination of the installation.

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c) Local Fire Regulations; and

d) Regulations of the Local Supply Authority

and the latest editions (current at the time of Tender) of all relevant South African National Standards, as well as International Standards, including but not limited to:

Table 1: Reference Standards

Standard Number	Description
SANS 32	Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants
SANS 97	Electric cables – Impregnated paper insulated metal-sheathed cables for rated voltages 3,3/3,3kV to19/22kV (excluding pressure assisted cables)
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
SANS 156	Moulded-case circuit-breakers
SANS 164	Two-pole and earthing-pin plugs and socket outlets
SANS 475	Luminaires for interior lighting, streetlighting and floodlighting - Performance requirements
SANS 767	Earth leakage protection unit
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2.2.3 Where Standards of the same order are not in agreement with each other, the Standard with the most rigorous requirements shall apply.

2.2.4 The installation shall also comply with:

a) This Specification, including all Technical Data Sheets; and

b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

3. COMPONENTS AND EQUIPMENT

3.1 General

3.1.1 All equipment and components shall be suitable for their operating environment, particularly with respect to the following:

a) The degree of ingress protection against dust and moisture (IP rating)

b) The corrosion resistance of the materials of construction; and

c) Mechanical properties (especially impact strength)

3.2 Power Outlets

3.2.1 Commercial Socket Outlets

a) All socket outlets with switches shall fully comply with SANS 164 and SANS 60669-1.

b) Units for flush mounting shall be suitable for a 100 x 100 x 50 mm deep flush wall box. Surface mounted patterns shall be housed in heavy pressed steel boxes. Shutters shall be included on the live and neutral socket holes.

c) All socket outlets with switches shall be continuously rated at 16A and shall be suitable for operation on a 250V, 50 Hz, AC system.

d) Cover plates shall have bevelled edges which overlap the box.

e) Socket outlets and their cover plates must adhere to the following colour and earth pin convention:

i) White, with round earth pin, where outlets are protected by an earth leakage sensing device;

ii) Red, with shaved earth pin, where outlets are not protected by earth leakage sensing device (which outlets shall be referred to as "dedicated").

3.2.2 Industrial Socket Outlets

a) Plugs, couplers and socket outlets shall conform to the requirements of SANS 1239.

b) Where pilot connections are required, they shall disconnect before the main phase connectors disconnect.

c) 3-Phase Socket Outlets

i) 400V socket outlets shall be five poled (three phases, one neutral and one earth), incorporating isolation mechanically interlocked with the plug.

ii) The equipment enclosures shall be at least IP 55 to SANS 60529.

iii) All welding plugs and socket outlets shall be 5 poled (3-phase, plus neutral, plus earth).

d) Single Phase Outlets

i) 16 A, 250 V socket outlets shall be two pole and earth, incorporating isolation mechanically interlocked with the plug.

3.2.3 Local Isolators (Switch-disconnectors)

a) Local isolators shall be selected from the following:

i) Isolator in accordance with SANS 60947-3, complete with additional late-make, early-break auxiliary contacts as required

ii) Plug and socket assembly to SANS 60309-1 and SANS 60309-2, incorporating isolation mechanically interlocked with the plug; or

iii) Plug and socket assembly to SANS 60309-1 incorporating a de-contactor arrangement or additional late-make early-break auxiliary contacts.

4. INSTALLATION OF COMPONENTS AND EQUIPMENT

4.1 General

4.1.1 Final positions of equipment shall be agreed with the Engineer on site, prior to installation.

4.1.2 All equipment shall be securely mounted using propriety (i.e. suited to and manufactured for such use) fixtures and fittings.

4.1.3 The method of equipment installation shall not adversely affect the function or structural integrity of the structure to which the equipment is attached.

4.1.4 Equipment terminals and covers shall be readily and safely accessible after installation.

4.1.5 The method of equipment installation shall not adversely affect the IP rating of the equipment.

4.1.6 No horizontal chasing shall be allowed into brick or concrete work.

4.1.7 It is the Contractor's responsibility to work closely together with the relevant parties responsible for the civil construction work to establish coordination in the installation program of components and conduits, as well as to establish a neat installation showing no indication of 'last minute changes'. Modification to existing structures shall be approved by the Engineer.

4.1.8 Framework and Brackets

a) Site-fabricated framework and brackets shall not be used.

b) Framework and brackets shall be positioned so as not to adversely affect the removal and replacement of equipment.

c) Where it is necessary to modify on site any pre-fabricated galvanised mild steel framework, the cut edges shall be dressed and treated immediately with an approved cold-galvanising paint to prevent corrosion.

4.1.9 Fasteners

a) Fasteners securing equipment to framework and brackets shall be independent of those securing framework and brackets to walls and floors.

b) No electroplated fasteners will be allowed. Only hot dipped galvanised or stainless steel fasteners will be allowed.

4.1.10 Positioning of Equipment

a) Equipment shall be positioned with due regard to the aesthetics of the installation.

b) Equipment (e.g. outlets, switches, distribution boards, etc.) shall be installed plumb. If an imaginary line is drawn from the vertical side of any such component, the deviation of such imaginary line from the vertical shall not exceed ± 5 mm for every 1 m increase in height, with a maximum deviation from the vertical of ± 10 mm.

c) The permissible deviation from the mounting heights indicated for equipment covered by this document shall be ± 10 mm, with a maximum of ± 5 mm deviation from the horizontal between adjacent outlets, isolators, luminaires, assemblies and / or switches.

d) Where a group comprises a number of items at different mounting heights, with not more than one item at any one height, then all items shall be sited on a common vertical centre line.

e) Where a group comprises a number of items mounted at the same height, then all items shall be sited on a common horizontal centre line.

f) Where a group comprises a number of different sized items they shall be arranged with the largest item at one end of the group and a progressive reduction in size of the remaining items.

g) Where a group comprises a number of items at different mounting heights with more than one item at any height, then a common vertical centre line shall be established and the items arranged on, or symmetrically about, this centre line.

h) Where a group comprises a number of items at the same mounting height with more than one item at the same position, then a common horizontal centre line shall be established and the items arranged on, or symmetrically about, this centre line.

4.1.11 Mounting height of Components

Mounting heights shall be as follows unless otherwise specified:

Table 2: Mounting height of components

Distribution boards	Top frame 2000 mm above finished floor level, except where the board may be accessible to infants, where then the bottom frame shall be 1200 mm above finished floor level
Switches	All security controls and light switches shall be horizontally aligned with door handles and other fixtures and fittings (other than socket outlets) between 900 mm and 1,2 m above the finished floor level
Socket outlets	See b)
Telephone outlets	Underside 500 mm above finished floor level

4.1.12 All distribution boards, switches and socket outlets shall be of the flush mounted type.

4.2 Installation of Socket Outlets

4.2.1 General

a) The Contractor should only start installation of power outlets in the conduit outlets after plasterers and painters have completed their work in the vicinity of the outlet.

b) Socket outlets shall be installed at the following heights above finished floor level, measured to the underside of the outlet:

i) 500 mm above finished floor level for general applications

ii) 500 mm above fixed ground level where they are to be installed outside buildings

iii) 1200 mm above finished floor level in kitchens

iv) 300 mm above counter tops

4.2.2 Connections to geysers

a) Each geyser shall be connected to a separate circuit with a separate earth conductor.

b) The conduit from the distribution board shall terminate in a 100 x 100 x 50 mm outlet box within 1 metre of the geyser. A suitably rated double pole isolator shall be installed in the outlet box. A flexible length of conduit shall be installed between the isolator and the geyser.

4.2.3 Connections to heaters, fans, air conditioners and hand blowers

a) A suitably rated double pole isolator shall be supplied and installed within 1 metre of heaters, fans and air conditioners. Where the equipment is out of reach the isolator, which must then be of the type capable of being locked in the open position, shall be installed 1,5 m above floor level, and a sign indicating location of the isolator shall be fixed onto or next to the equipment that it switches. Flexible cords may be used for the final connection to the equipment, provided the cables are correctly current rated.

b) Where control units (for HVAC, BMS, etc.) are to be installed, the units shall be installed 1,5 m above the finished floor level.

4.3 Installation of Telecommunication Services and Accessories

4.3.1 Telephone distribution boards

a) Telephone distribution boards are to be installed with their bottom frames 1 200 mm above finished floor level.

b) All conduits and sleeves to telephone outlets or telephone sub-distribution boards in the buildings or elsewhere on the site, as well as the main incoming sleeves, shall terminate at the main telephone distribution board, as shown on the relevant drawing.

4.3.2 Separation of services

a) Wireways provided for telecommunication or other related services shall under no circumstances be used for any other purpose.

b) Power cables, conductors and accessories shall be installed at a minimum distance of 300 mm away from the routes reserved for telecommunication cables.

c) Conduits and other channels shall be installed in such a way as to avoid telecommunication cables from crossing power cables.

4.4 Telecommunication outlets

a) Telephone and / or data outlets in walls shall comprise of 100 x 100 x 50 mm deep wall boxes which shall be flush mounted in the wall, in the position shown on the relevant drawing, with the underside fixed 500 mm above the finished floor level. The wall box shall be fitted with a white coloured blank cover plate.

b) All outlet boxes shall align neatly with adjacent socket outlet wall boxes.

c) Outlets in floors fitted with floor ducting shall be of the same type as the floor outlets for power socket outlets, and shall be provided in the same outlet box.

d) Outlets in power skirting shall be provided at the positions indicated on the relevant drawing, and the Contractor need only provide a separate short length power skirting cover at these positions. The cover for the fixing of outlet shall not exceed 250 mm in length, and shall be secured in such a manner that adjacent cover plate sections can be removed without disturbing the telephone outlet.

5. WIREWAYS

5.1 Conduit

5.1.1 Plain-end metallic conduit and accessories

a) Plain-end conduit shall be manufactured from mild steel having a minimum wall thickness of 0,9 mm and shall comply with SANS 60614.

b) Galvanised conduits shall be hot-dipped on both the internal and external surfaces, in accordance with SANS 121.

c) Epoxy powder-coated metal conduit may not be used in installations where bending of conduit will be required (unless prior approval of use has been granted by the Engineer).

d) Bending and setting of plain-end conduit shall be undertaken using the correct bending apparatus as recommended by the manufacturer of the conduit. After the bending of galvanized conduit, cold galvanizing paint shall be applied.

5.1.2 PVC conduit and accessories

a) PVC conduit shall comply with SANS 950 and shall bear the SABS mark.

b) PVC conduit shall be constructed from rigid PVC. PVC conduit shall be white in colour and shall be non-flammable. The minimum softening temperature shall be 75 °C.

c) All PVC conduit accessories shall be fully in accordance with SANS 950 and shall bear the SABS mark.

5.1.3 Flexible conduit

a) Flexible steel conduit and adaptors shall comply with IEC 50086 where applicable.

b) Flexible steel conduit shall be of a galvanised steel construction. It does not need to be waterproof, but shall be vermin proof and suitable for protection of cables against mechanical damage.

c) In moist or damp areas, flexible steel conduit shall be of the plastic sheathed galvanised steel type.

d) Flexible polypropylene tubing shall only be fastened to PVC conduit installations.

5.1.4 Conduit Accessories

a) Earth clamps

i) Earth clamps shall comprise of copper strips having a minimum thickness of 1 mm and shall not be less than 12 mm wide. Earth clamps shall be provided complete with a 25 mm x 4 mm brass bolt, washer and nut and shall be constructed such that the clip can be firmly attached to the conduit without the need for any additional packing.

b) Flush mounted wall boxes

i) Flush mounted PVC wall boxes shall be manufactured from rigid PVC and shall be white in colour. All PVC wall boxes shall comply with SANS 950.

ii) Flush mounted steel wall boxes shall be manufactured from heavy gauge sheet steel and shall be galvanised. All steel wall boxes shall comply with SANS 1085.

iii) The boxes shall be provided with the necessary mounting lugs to suite the units for which the box is intended and be provided with 20 mm knock-outs.

iv) Facilities shall be provided for the fixing of earth terminals to the box.

c) Round group-type circular boxes

i) Steel round boxes shall be manufactured in accordance with SANS 1065 and shall be of the long spout pattern, constructed from either store enamelled jet black or galvanised steel, or from malleable cast iron.

ii) PVC round boxes shall be manufactured in accordance with SANS 950 and of the same dimensions, but having web-reinforced spouts.

iii) The two cover fixing holes of both steel and PVC boxes shall be diagonally opposite each other, and shall be drilled and tapped at 50 mm centres. Internal dimensions shall be approximately 60 mm in diameter by 60 mm deep for use in concrete work. Shallower boxes shall be used in open roof spaces.

iv) The cover screw pillars shall be provided with tapped brass inserts and provision shall be made for a brass earthing terminal adjacent to one or both of the pillars.

v) PVC round box covers shall be of PVC and shall be secured by means of brass screws at 50 mm centres.

d) Draw wires

i) Draw wires for unused conduits shall either be galvanised steel wire or nylon, but shall have a minimum diameter of 2 mm.

5.1.5 Conduit Installation

a) General

i) The conduit installation shall comply with par. 6.5 of SANS 10142-1.

ii) Where the conduit installation is surface mounted, space-bar saddles must be used in order to provide an air gap between the conduit and mounting surface.

iii) The conduit system shall be mechanically continuous, secure and rewireable.

iv) All unused, screwed entries shall be fitted with a blanking plug. Female PVC bushes shall be fitted to all free ends.

v) Conduits shall not be used to support the weight of fittings etc., except where specifically designed to do so. Conduit boxes supporting luminaires or accessory boxes shall be fixed to the fabric of the building independently of the conduit.

vi) Sufficient conduit and drawing boxes shall be provided to facilitate cable installation and removal. In general, no more than 2 bends or off-sets or one coupling shall be permitted without a conduit box.

vii) Steel conduit shall not be relied upon for earth continuity

viii) All PVC conduits shall be installed in accordance with Appendix C, SANS 950.

ix) Draw boxes should be as far as possible be placed out of sight and shall be indicated on the "as built" drawings.

x) The edge of flush mounted outlet boxes shall not be deeper than 10 mm from the final surface. Where necessary, spacer springs shall be used under screws.

xi) Oversize cover plates shall be provided on all flush mounted round conduit boxes, where required. Surface mounted boxes shall be provided with standard size cover plates.

b) Flexible conduit

i) In installations where the equipment has to be moved frequently to enable adjustment during normal operation, for the connection of motors or any other vibrating equipment, for the connection of thermostats and sensors on equipment, for stove connection and where otherwise required, flexible conduit shall be used for the final connection to the equipment.

ii) Flexible conduit shall be connected to the remainder of the installation by means of a draw box. The flexible conduit may be connected directly to the end of a conduit if an existing draw box is available within 2 m of the junction and if the flexible conduit can easily be rewired.

iii) Flexible conduit shall consist of metal reinforced plastic conduit or PVC covered metal conduit with an internal diameter of at least 15 mm, unless approved to the contrary. In false ceiling voids, flexible conduit of galvanised steel construction may be used. Connectors for coupling to the flexible conduit shall be of the gland or screw-in type, manufactured from either brass or mild steel plated with zinc or cadmium.

c) Installation in concrete

i) In order not to delay building operations, the electrical Contractor shall ensure that all conduits and accessories which are to be cast in concrete are placed in position in good time. The Contractor or his representative shall be in attendance when the concrete is cast.

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

iii) Sharp bends and elbows for conduits of 32 mm diameter will not be allowed in concrete slabs.

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

v) All conduits shall be installed as close as possible to the neutral axis of concrete beams, slabs and columns. The conduits shall be rigidly secured to the reinforcing to prevent movement towards the surface of the concrete.

vi) All conduits, draw boxes, etc., shall be securely fixed to the shuttering to prevent displacement when concrete is cast. Draw boxes and outlet boxes shall preferably be secured by means of a bolt and nut installed from the back of the box through the shuttering. Fixing lugs may also be used to screw the boxes to the shuttering where off-shutter finishes are required. Where fibre glass shuttering is used by the builder, the equipment shall be fixed to the steel only and no holes shall be drilled or made in shuttering. All draw boxes and outlet boxes shall be plugged with wet paper before they are secured to the shuttering.

vii) As far as possible, conduits shall not be installed across expansion joints. Where this is unavoidable a conduit expansion joint shall be provided. The expansion joint shall consist of two draw boxes with an interlinking flexible conduit connection. The draw box shall be installed adjacent to the expansion joint of the structure and a conduit sleeve, one size larger than that specified for the circuit, shall be provided on the side of the draw box nearest to the joint. The one end of the sleeve shall terminate at the edge of the joint and the other shall be secured to the draw box. The circuit conduit passing through the sleeve shall be terminated 40 mm inside the draw box, and, in the case of metallic conduit, the conduit end shall be fitted with a brass bush. The gap between the sleeve and the conduit at the joint shall be sealed with TiC-TaC (Titanium Carbide / Tantalum Carbide) or equal sealing compound, to prevent the ingress of wet cement. The other end of the circuit conduit shall be secured to the draw box by means of a standard bushed adaptor for other PVC types. The cover plates shall be installed before the ceiling is painted. Where a number of conduits are installed in parallel they shall cross the expansion joint of the structure via a single draw box. A number of draw boxes adjacent to each other will not be allowed.

viii) The installation of conduits in floor screed shall be kept to a minimum. Where conduits are installed in screed, the top of the conduit shall be at least 20 mm below the surface of the screed. Where the screed is laid directly on the ground, galvanised conduits shall be used. A minimum distance of twice the outside diameter of the conduit shall be left free between adjoining conduits. Conduits shall be secured to the concrete slab at intervals not exceeding 2,0 m. The Contractor shall ensure that conduits are not visible above the screed where the conduits leave the screed.

ix) All draw boxes, conduits, etc., which are installed in concrete shall be cleaned with compressed air and provided with draw wires two days after removal of the shuttering. Errors that occurred during the installation of the conduits, or any lost draw boxes or blocked conduits shall be reported to the Engineer immediately.

x) Where it is necessary to cut or drill holes in the concrete structure, prior permission shall be obtained from the Engineer in writing.

d) Installation in brickwork

i) Recessed conduits and accessories installed in brickwork shall be built-in. In order not to delay building operations the Contractor shall ensure that all conduits and accessories which are to be built-in are placed in position in good time.

ii) Any conduit draw boxes, outlet boxes, etc., which have been damaged, lost or omitted, shall immediately be reported to the Engineer.

e) Surface and roof space installations

i) All conduits shall be installed horizontally or vertically as determined by the route. The electrical Contractor shall take all measures to ensure a neat installation.

ii) Conduits shall be firmly secured by means of saddles and screws and in accordance with SANS 10142, par. 5.4.2(b). Conduits shall be secured within 150 mm before and after each 90° bend.

iii) Only approved plugging materials, such as fibre plugs or plastic plugs, etc., and round head screws shall be used when fixing saddles, switches, plugs etc., to walls. Wood plugs are not acceptable, nor should plugs be installed in joints in brick walls.

f) Chasing and builder's work

i) Except where the project involves upgrading existing facilities, all flush mounted conduits, accessories, switchboard trays, bonding trays etc., shall be built-in and no chasing shall be allowed.

5.1.6 Installation of Cables in Conduit

a) The cable installation in the conduit shall conform to par 6.5.6 of SANS 10142-1 and other portions of SANS, where applicable.

b) Conduit shall be deburred and swabbed prior to cables being pulled in.

c) Cables of other classifications and purpose (e.g. DC, Fire Detection, Audio, etc.) shall be installed in separate conduits.

d) Circuits supplied from different distribution boards shall not be installed in the same conduit.

e) Final sub-circuits shall not be installed in the same conduit as sub-mains circuits.

5.2 Power Skirting

5.2.1 Construction

a) Power skirting must comply with all relevant parts of SANS 61084.

b) Except where room dimensions dictates shortening thereof, in which case only one length per wall may be trimmed, power skirting and covers shall be installed in their standard (manufactured) lengths.

c) The covers shall either snap on, or shall be fixed by means of toggle or swivel nuts.

d) Only socket outlets that are compatible for use with the particular type of power skirting may be used.

e) Propriety internal and external bends, and off-sets of the same manufacture and product range, shall be used.

f) Over and above the requirements of SANS 10142-1, all conductive power skirting that will contain telecommunication and / or control wiring shall be bonded in accordance with NRS 083-2 (details bonding methods that provide enhanced protection against the effects of electromagnetic cross-interference).

5.2.2 Installation

a) Conduits for the circuit wiring to the power skirting must terminate in flush conduit boxes behind the power skirting at the respective heights of the compartments for the telephone, power and other service compartments.

b) Notwithstanding the requirement to provide adequate capacity for the installation of data and telecommunication cables, conduits installed to power skirting installations shall have a minimum of 50 % spare capacity, to allow for future expansion

c) The wiring shall pass through large diameter holes, suitably bushed, cut in the rear of the power skirting. Where metallic skirting is installed, the holes shall be provided with rubber grommets.

d) Where power skirting is interrupted by doorways, bridging conduits shall be installed for each of the service compartments.

e) To allow for the easy removal of plugs from outlets, in multi compartment installations the bottom compartment(s) shall be for telecommunication services and the top compartment(s) for power circuits.

5.3 PVC Cable Trunking

5.3.1 Construction

a) Cable trunking must comply with relevant parts of SANS 61084.

b) Cable trunking and covers shall be installed in their standard (manufactured) lengths, except at the end of runs as dictated by room dimensions.

c) The covers shall either snap on, or shall be fixed by means of toggle or swivel nuts.

d) Propriety internal and external bends, and off-sets of the same manufacture and product range, shall be used.

5.3.2 Installation

a) All wiring exiting cable trunking shall pass through large diameter holes, suitably bushed, cut in the rear of the trunking.

5.4 Wiring inside wireways

5.4.1 General

a) All unarmoured conductors shall be installed in conduits, trunking or power skirting, and such conductors shall not be exposed to possible mechanical damage.

b) Any debris and moisture inside of wireways shall be removed prior to the installation of conductors.

c) In the event that lubrication of cables is required in order to facilitate their installation, the lubricant shall be suitable for use with the type of cable as well as the type of wireway. The Contractor shall take steps to ensure that only the minimum amount of lubrication is applied. Should any seepage of lubricants into building elements or fixtures occur, it shall be the responsibility of the Contractor to remove the oil and fix the damaged building elements or fixtures, regardless of whether he installed the wireways or not.

5.4.2 Circuits

a) The circuits for the installation are indicated on the relevant drawings. Where not indicated on the drawings, the maximum number of points to be connected to each type of circuit shall be:

Table 3: Circuits

Light points per circuit	=	8
Single socket outlets per circuit	=	4
Extraction fan, Air conditioner points per circuit	=	2
Stove points per circuit	=	1

b) When determining the number of outlets per circuit, double socket outlets count as two single socket outlets.

c) In kitchens, the number of socket outlets per circuit shall be reduced to 2.

d) Where maintained emergency lighting are to be installed two live wires shall be installed to the luminaire:

i) The normal, switchable, circuit

ii) An unswitched circuit, for battery charging only

e) For 20 mm or small diameter conduit only one circuit will be allowed, with the exception of the wiring from switch boards to fabricated sheet metal boxes located close to switchboards, in which case more than one circuit will be allowed. For larger conduit sizes the requirements of SANS 10142, par. 6.5.6, shall be met.

5.4.3 Looping and joints

A loop-in wiring system, where conductors are looped from outlet to outlet, shall be employed. Joints in conductors shall be avoided as far as possible, but where it becomes unavoidable, joints will be accepted in conduits. Joints shall be soldered or shall alternatively consist of approved ferruling, properly covered with propriety heat-shrink sleeves. The use of PVC insulation tape is not acceptable.

5.4.4 Grouping of conductors

In cases where the conductors of more than one circuit are installed in the same wireway, the conductors of each separate circuit, including the circuit earth continuity conductor, shall be grouped at intervals of at least one metre using plastic cable ties. The conductors of different circuits shall however remain separate in order to ensure that any given circuit may be withdrawn from the wireway. Conductors entering distribution boards or control boards shall be grouped and bound by means of plastic cable bands. The use of PVC insulation tape for grouping conductors will not be accepted.

5.4.5 Pulling-through of conductors

The Contractor shall take utmost care whilst pulling conductors through conduit to ensure that the conductors are not kinked, twisted or strained in any manner. Care shall furthermore be taken to ensure that conductors do not come into contact with materials or surfaces that may damage or otherwise adversely affect the insulation and durability of the conductor.

5.4.6 Earth continuity conductors

a) Only stranded copper conductors, which shall be bare or PVC insulated (coloured green/yellow), shall be used as earth continuity conductors. Although it shall be terminated such that it can fulfil this function (except where inappropriate, as will be the case of single core cable installations), under no circumstances shall the armouring and/or shielding of cables be relied upon to provide protective earth continuity.

b) When earth continuity conductors are looped between the earth terminals of equipment, the looped conductor ends shall be twisted together and then ferruled or soldered to ensure that continuity is maintained when the conductors are removed from any earth terminal.

c) Where bare copper earth wires are specified for circuits installed in power skirting and floor ducting, the Contractor shall provide a suitable length of PVC sleeving over the bare earth conductor where it passes behind or is connected to power outlets, to ensure that such an earth conductor does not come into contact with any live parts.

5.4.7 Wiring inside vertical wireways

Conductors installed in vertical wireways shall be secured at intervals not exceeding 5 m to support the weight of the conductors. Approved clamps shall be supplied and installed in suitable draw-boxes for this purpose.

5.4.8 Conductor sizes

The following minimum conductor sizes shall be used:

Table 4: Conductor sizes

Circuit	Minimum Conductor (Size)	
	Phase (mm^2)	Earth (mm^2)
Lighting	2,5	2,5
Socket outlet	2,5	2,5
Stove	6	6
Bell	1,5	1,5
Clock	1,5	1,5
Air conditioner	4	2,5
Control Wiring	1.5	1.5

5.4.9 Single pole switches

Single pole switches shall only be connected to the phase conductor (never the neutral conductor).

5.4.10 Three phase outlets

a) With the exception of three phase outlets, wiring to circuits connected to different phases shall not normally be present at lighting, switch or socket outlet boxes. Where this is unavoidable, barriers shall be provided between terminals or connections of the various phases and the box shall be suitably labelled internally to indicate the presence of line voltages.

b) A separate neutral conductor shall be installed together with each three phase circuit to outlets intended for equipment connection by means of isolators or socket outlets, irrespective of whether the particular equipment may require a neutral or not.

6. DRAWINGS AND DOCUMENTATION

6.1 General

6.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

a) The Client's name and contact details

b) Client's project / scheme / contract reference title and numbers

c) The Engineer's name and contact details

d) Engineers reference numbers

e) Contractor's works / contract / order references.

6.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

6.2 Drawings for Approval

6.2.1 The following documentation and drawings shall be submitted to the Engineer prior to the installation of cables and wireways and before civil construction have started on the areas where cable routes are required:

a) Cable route layout drawings showing

i) Type of wireways

ii) Trenching

iii) Cable junction boxes

6.3 As-built Drawings

6.3.1 Detailed "as-built" drawings, clearly labelled as such, and consisting of 3 sets of drawings printed to their original size, and, where the original drawings were larger than A3, 3 sets of drawings printed (with reduced scaling, but without omitting any information from the printed area), to A3, shall be provided by the Contractor, indicating positions of the following:

a) Equipment (e.g. light fittings, draw boxes, outlets etc.)

b) Wireways (e.g. trenches, conduit, cables ladder/trays, power skirting etc.); and

c) Cable routes (including any cable joints)

d) General arrangement drawings

e) Single Line Diagrams

6.4 Operating and Maintenance Manual

6.4.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied. The manuals shall be in A4 format.

6.4.2 The operating and maintenance manuals shall include at least the following:

a) A schedule of installed components and equipment, containing the following information:

i) Manufacturers name and contact details

ii) Circuit number (DB name, circuit breaker e.g. DB01-CB08); and

iii) Function (e.g. switching lighting circuit DB03-L1)

b) A schedule of all installed cables, with the following information:

i) Circuit number (DB name, circuit breaker e.g. DB01-CB08)

ii) Size

iii) Installed length; and

iv) Function (e.g. “Feeding Submersible pump IW-SP-01”)

c) Description and details w.r.t:

i) Detailed description of the function of all operator controls

ii) Procedures for fault finding

iii) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures

iv) Inspection schedules; and

v) Spare part information and recommended spares.

7. TESTING AND COMMISSIONING

7.1 General

7.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.

7.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.

7.1.3 The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall comply with SANS 61010 and be covered by a current test and calibration certificate.

7.1.4 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.

7.1.5 Unless otherwise specified in the Particular Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10142-1.

7.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Particular Specification, the period of notice for witness testing shall be 5 working days.

7.1.7 Where most of the inspection and testing activities are not witnessed, the Contractor shall allow for 10 % of the inspection and testing activities to be repeated for witness testing.

7.1.8 If there is a requirement for additional inspection and test activities to be performed as part of process commissioning, this shall be specified in the Particular Specification.

7.1.9 Unless otherwise agreed by the Employer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

7.2 Test Sequence

7.2.1 Inspections before Testing

Before testing, inspections shall be performed to verify:

a) All equipment and material is of the correct type and complies with applicable SANS and IEC standards

b) All parts of the installation are correctly selected and erected

c) No part of the installation is visibly damaged or otherwise defective

d) The installation is suitable for the environmental conditions; and

e) The installation complies with this Specification

7.2.2 Testing of Installation

On satisfactory completion of the inspections specified in 7.2.1 the following tests shall be undertaken in the sequence listed as per SANS 10142-1:

a) Continuity of conductors

b) Resistance of Earthing conductor

c) Continuity of ring circuits Earth fault loop impedance at main switch

d) Elevated voltage on supply neutral Earth Resistance

e) Insulation resistance

f) Voltage, main distribution board - no load

g) Voltage, main distribution board - on load

h) Voltage at available load

i) Operation of earth leakage units

j) Earth leakage test button

k) Polarity at points of consumption

l) Switching devices

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1. SCOPE

1.1 Application

1.1.1 This document specifies the standard requirements for the design, installation, testing and commissioning of electrical installations operating on voltages up to 1 000 Volts AC / 1 500 Volts DC.

1.1.2 The primary intention of this specification is to ensure the provision of an electrical installation, which has been designed and constructed to ensure safe, reliable, operation and to facilitate safe inspection, testing and maintenance.

1.1.3 Note however, that this specification only covers such installations (or sections of installations) that are covered by SANS 10142-1. Note also, that certain provisions of this specification are inappropriate for direct application to installations where additional measures (such as earthing, intrinsic safe equipment, etc.) are required by SANS 10142-1 and SANS 10108 (i.e. medical and hazardous locations). For these types of installations, thorough reference must be made to the relevant statutory documentation.

1.2 Electrical System Characteristics

1.2.1 The design of the installation shall comply with SANS 10142-1.

1.2.2 The design of the installation shall consider the following supply characteristics:

a) Voltage, frequency and number of phases

b) Maximum prospective short circuit current (phase to phase and phase to neutral)

c) Type of system, e.g. TN-S, TN-C-S

d) Maximum earth loop impedance of the earth fault path external to the installation

e) Type and rating of the cut-out or switch device

f) Load capability of the supply source, particularly the effects on the supply voltage of the starting of new equipment and any fault contributions from new equipment

1.2.3 The installation protective devices shall be correctly co-ordinated within the installation and with respect to existing installations. Discrimination studies shall be performed to validate the co-ordination of the installation.

1.2.4 All equipment which requires operation or attendance by a person, or requires cleaning or maintenance in service, shall be constructed and installed to allow adequate and safe means of access and working space for such activities. Similarly, the positioning of equipment shall not impede access to, or working space at, non-electrical equipment and services for operation and maintenance activities.

1.2.5 The installation shall be suitable for access and use by electrically unskilled persons.

1.2.6 Where additions or alterations to an existing installation are to be performed, the rating and condition of existing equipment, including that associated with the supply, shall be verified to confirm its suitability to carry any additional load. The earthing and equipotential bonding arrangements shall also be verified. No addition or alteration shall have an adverse effect on the existing installation.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Particular Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.

2.1.2 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.

2.1.3 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the Installation.

2.2 Regulations, Specifications and Standards

2.2.1 The design, construction, inspection and testing of the installation shall comply with all relevant Statutory Regulations and Directives including:

a) Occupational Health and Safety Act (Act 85 of 1993)

b) Construction Regulations 2003 issued in terms of Section 43 of the Act

c) Local Fire Regulations; and

d) Regulations of the Local Supply Authority

and the latest editions (current at the time of Tender) of all relevant South African National Standards, as well as International Standards, including but not limited to:

Table 1: Reference Standards

Standard Number	Description
SANS 32	Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants
SANS 97	Electric cables – Impregnated paper insulated metal-sheathed cables for rated voltages 3,3/3,3 kV to19/22 kV (excluding pressure assisted cables)
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
SANS 156	Moulded-case circuit-breakers
SANS 164	Two-pole and earthing-pin plugs and socket outlets
SANS 475	Luminaires for interior lighting, streetlighting and floodlighting - Performance requirements
SANS 767	Earth leakage protection unit
SANS 950	Unplasticized polyvinyl chloride rigid conduit and fittings for use in electrical installations
SANS 1063	Earth rods, couplers and connections
SANS 1085	Wall outlet boxes for the enclosure of electrical accessories
SANS 1088	Luminaire entries and spigots
SANS 1091	National colour standards of Paint
SANS 1195	Busbars
SANS 1213	Mechanical cable glands
SANS 1239	Plugs, socket-outlets and couplers for industrial purposes
SANS 1266	Ballasts for discharge lamps (excluding tubular fluorescent lamps)

Standard Number	Description
SANS 1411	Materials of insulated electric cables and flexible cords
SANS 1431	Weldable structural steels
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SANS 1700	Fasteners
SANS 1777	Photoelectric control units for lighting
SANS 1783	Sawn softwood timber
SANS 1973	Low-voltage switchgear and controlgear Assemblies
SANS 2001	Construction Works
SANS 10155	Accuracy in buildings
SANS 10199	The design and installation of earth electrodes
SANS 10225	The design and construction of lighting masts
SANS 10177	Fire testing of materials, components and elements used in buildings Part 2: Fire resistance test for building elements
SANS 10142-1	Wiring of Premises Part 1: Low Voltage Installations
SANS 10400	The application of the National Building Regulations
SANS 60269	Low-voltage fuses
SANS 60309	Plugs, socket-outlets and couplers for industrial purposes
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 60614-2	Conduits for electrical installations - Particular specification for conduits
SANS 60669	Switches for household and similar fixed-electrical installations
SANS 60947	Low-voltage switchgear and controlgear
SANS 61000	Electromagnetic compatibility (EMC)
SANS 61010	Safety requirements for electrical equipment for measurement, control, and laboratory use
SANS 61048	Auxiliaries for lamps - Capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements
SANS 61238	Compression and mechanical connectors for power cables for rated voltages up to 30 kV(Um = 36 kV)
SANS 61643	Low-voltage surge protective devices
Other Standards	**Description**
ARP 035	Guidelines for the installation and maintenance of street lighting
BS 88	Specification of supplementary requirements for fuses of compact dimensions for use in 240 / 415 V industrial and commercial electric installations
IEC 157	Low voltage switchgear and control gear
IEC 408	Low voltage air-break switches, air-break disconnectors, air-break switch disconnectors and fuse combination units
IEC 12373	Aluminium and aluminium alloys. Anodizing. Method for specifying decorative and protective anodic oxidation coatings on aluminium
IEC 50086	Conduit systems for cable management
IEC 60898	Specification for circuit-breakers for overcurrent protection for household and similar installations

2.2.2 Standards are often tailored to the conditions of their country or origin (in terms of permissible voltages, expected ambient temperatures, etc.). Therefore, and unless normatively referenced to the contrary in a Standard of higher precedence, the decreasing order of precedence of Standards shall be:

a) South African National Standards (SANS, VC, etc.)

b) South African Sectoral Standards and Specifications (NERSA, CKS, ARP, NRS, PIESA, etc.)

c) ISO Standards

d) IEC Standards

e) Harmonized British Standards (BS EN)

f) Other Harmonized European National (EN) Standards (CEN, CENELEC, ETSI)

g) Non-Harmonized British Standards (BS)

h) Other international standards

2.2.3 Where Standards of the same order are not in agreement with each other, the Standard with the most rigorous requirements shall apply.

2.2.4 The installation shall also comply with:

a) This Specification, including all Technical Data Sheets; and

b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

3. COMPONENTS AND EQUIPMENT

3.1 Lighting and Accessories

3.1.1 Luminaires

a) Luminaires shall comply with SANS 60598 (relevant parts).

b) Luminaires shall be supplied complete with lamps of a type suitable for the luminaire design.

c) Upon the Engineer's request, simulation data files must be made available for each luminaire.

3.1.2 Control Gear and Enclosures

High frequency, electronic control gear shall be used for tubular (double capped) and compact (single capped) fluorescent lamps, and, where appropriate, for discharge lamps.

3.1.3 Switches

a) Flush mounted switches

i) Flush mounted switches shall comply with SANS 60669-1 and shall bear the SABS mark.

ii) All flush mounted switches shall be suitable for mounting in 100 x 50 x 50 mm galvanised steel or PVC wall boxes.

iii) The switch mechanism shall be of the tumbler-operated micro-gap type with silent operation, and shall be rated for 16 A continuous loading at 50 Hz and 250 V.

iv) Switches shall have protected terminals for safe wiring. Multi-lever switches shall be constructed so as to enable individual defective switches to be removed and replaced without having to remove the remaining switches.

v) The mounting holes provided on the yoke strap shall be slotted to allow for easy alignment. A brass earthing terminal shall furthermore be provided on the yoke to ensure the positive earthing of the switch assembly.

b) Cover plates for switches

i) Cover plates for flush mounted switches shall have levelled edges which overlap the wall box in order to conceal all wall imperfections.

c) Surface mounted switches

i) Surface mounted switches shall comply with SANS 60669-1 and shall bear the SABS mark.

ii) Surface mounted switches shall consist of single or multiple switches, not exceeding four, and shall be mounted in a pressed steel box of heavy duty construction.

iii) The switch mechanism shall be of the tumbler operated micro-gap type with silent operation and shall be rated for 16 A continuous loading at 250 V and 50 Hz.

iv) A brass earthing terminal shall furthermore be provided on the switch construction to ensure the positive earthing of the switch assembly and enclosure.

v) The covers of surface mounted switches shall have toggle protectors.

d) Photo-Electric daylight switches

i) The unit shall comprise a photo-cell, thermal actuator and change-over switch. The cover of the unit shall be manufactured from a tough, durable material providing protection against tampering. The cover shall have good weathering properties. It shall be ultra violet resistant and shall not deteriorate when exposed to sunlight for prolonged periods.

ii) The units shall be capable of operating in dusty conditions, and over an ambient temperature range - 15 °C to + 55 °C.

iii) The units shall be designed to withstand damage by hail and stones thrown by vandals. If the units do not possess this quality, separate wire screens shall be provided for this purpose.

iv) All parts shall be treated to be corrosion-proof.

v) The operation level shall be factory pre-set for "ON" at a light level of 60 lux and "OFF" at 90 lux, with a permissible deviation of 12 lux either way. Voltage variations shall not materially affect the operational levels.

vi) A time delay, of not less than 15 seconds, shall be provided to prevent the unit from functioning due short-duration changes in illumination, such as lightning.

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

viii) The unit shall be of the wall mounting type and shall be supplied complete with a suitable bracket.

ix) The change-over switch shall be capable of switching 10 A AC at 250 V.

e) Dimmer modules

i) Dimmer modules shall comply with SANS 60929.

ii) Units shall be rated at 250 V, and capable of powering inductive (minimum power factor of 0.65 lagging) and capacitive (minimum power factor of 0.75 leading) loads.

iii) The efficiency of modules may not be less than 95 %, and the harmonic current injection not more than 1 % THD, at full load (where such load is resistive).

iv) Furthermore, the units shall be provided with automatic over-temperature, over-current and short-circuit cut-out features. Where over-current of short duration is expected (i.e. luminaire starting current), over-current protection may be by way of self-regulation (i.e. a reduction in output voltage).

v) Dimmer modules shall be sound-attenuated, such that audible noise is limited to 30 dB (all weightings) measured at a distance of 1 m from the module.

vi) The output of modules shall be controlled by propriety pushbutton-type switches. An additional switch, located in the same enclosure as the pushbutton, shall be provided for switching the input to the dimmer module.

vii) Unless prior approval in this regard has been gained from the Engineer, dimmer modules may not be paralleled.

viii) Dimmer modules shall be selected and installed such that 30 % spare capacity will be available for future additions to the output circuitry.

4. INSTALLATION OF COMPONENTS AND EQUIPMENT

4.1 Installation of Lighting and Accessories

4.1.1 Mounting of light fittings

a) Surface mounted down light holders, such as the bayonet / screw-in type lamp holders used for incandescent fittings, shall be screwed to the ceiling by means of at least two 4 mm diameter self-tapping screws. Plastic expansion plugs, of good quality, are to be used where the surface is concrete, plaster or brick. For suspended and soft ceilings, a solid timber backing strip of at least 40 x 40 mm timber must be supplied and installed between supports, with the screws fixed to these backing strips.

b) Channelled fittings, such as fluorescent fittings, shall be firmly mounted to ensure close contact with the ceiling over the entire length of the fitting. On concrete slabs the fittings shall be mounted by means of two screws into the ceiling conduit box, as well as two round-headed 4 mm x 30 mm electroplated self-tapping screws and plastic expansion plugs, one at either end. Where fittings are to be installed underneath suspended ceilings, they shall be mounted in an equal manner, but timber backing strips of at least 40 x 40 x 450 mm (at both ends) shall be placed in position on top of the ceiling board and the end screws secured to these strips, such that the weights of the fittings distribute evenly.

c) To ensure the safety of people below, where fittings are clamped or bolted directly to trusses or other building elements (as in the case of some high bay and floodlight installations) they shall be provided with an additional safety chain or safety cable of appropriate corrosion-proof material. This safety cable / safety chain assembly shall be connected independently of the luminaire-supporting clamps or bolts, such that either assembly can be loosened and removed without affecting the other. The safety assemblies shall have a load safety factor not less than 3.

d) Specialized light fittings (i.e. types of fittings not mentioned in this specification) must be installed strictly in accordance with their manufacturer's requirements and guidelines.

5. DRAWINGS AND DOCUMENTATION

5.1 General

5.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

a) The Client's name and contact details

b) Client's project / scheme / contract reference title and numbers

c) The Engineer's name and contact details

d) Engineers reference numbers

e) Contractor's works / contract / order references.

5.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

5.2 Drawings for Approval

5.2.1 The following documentation and drawings shall be submitted to the Engineer prior to the installation of cables and wireways and before civil construction have started on the areas where cable routes are required:

a) Cable route layout drawings showing:

i) Type of wireways

ii) Trenching

iii) Cable junction boxes

5.3 As-built Drawings

5.3.1 Detailed "as-built" drawings, clearly labelled as such, and consisting of 3 sets of drawings printed to their original size, and, where the original drawings were larger than A3, 3 sets of drawings printed (with reduced scaling, but without omitting any information from the printed area), to A3, shall be provided by the Contractor, indicating positions of the following:

a) Equipment (e.g. light fittings, draw boxes, outlets etc.)

b) Wireways (e.g. trenches, conduit, cables ladder/trays, power skirting etc.); and

c) Cable routes (including any cable joints)

d) General arrangement drawings

e) Single Line Diagrams

5.4 Operating and Maintenance Manual

5.4.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied. The manuals shall be in A4 format.

5.4.2 The operating and maintenance manuals shall include at least the following:

a) A schedule of installed components and equipment, containing the following information:

i) Manufacturers name and contact details

ii) Circuit number (DB name, circuit breaker e.g. DB01-CB08); and

iii) Function (e.g. switching lighting circuit DB03-L1)

b) A schedule of all installed cables, with the following information:

i) Circuit number (DB name, circuit breaker e.g. DB01-CB08)

ii) Size

iii) Installed length; and

iv) Function (e.g. “Feeding Submersible pump IW-SP-01”)

c) Description and details w.r.t:

i) Detailed description of the function of all operator controls

ii) Procedures for fault finding

iii) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures

iv) Inspection schedules; and

v) Spare part information and recommended spares

6. TESTING AND COMMISSIONING

6.1 General

6.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.

6.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.

6.1.3 The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall comply with SANS 61010 and be covered by a current test and calibration certificate.

6.1.4 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.

6.1.5 Unless otherwise specified in the Particular Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10142-1.

6.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Particular Specification, the period of notice for witness testing shall be 5 working days.

6.1.7 Where most of the inspection and testing activities are not witnessed, the Contractor shall allow for 10 % of the inspection and testing activities to be repeated for witness testing.

6.1.8 If there is a requirement for additional inspection and test activities to be performed as part of process commissioning, this shall be specified in the Particular Specification.

6.1.9 Unless otherwise agreed by the Employer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

6.2 Test Sequence

6.2.1 Inspections before Testing

Before testing, inspections shall be performed to verify:

a) All equipment and material is of the correct type and complies with applicable SANS and IEC standards

b) All parts of the installation are correctly selected and erected

c) No part of the installation is visibly damaged or otherwise defective

d) The installation is suitable for the environmental conditions; and

e) The installation complies with this Specification

6.2.2 Testing of Installation

On satisfactory completion of the inspections specified in 6.2.1 the following tests shall be undertaken in the sequence listed as per SANS 10142-1:

a) Continuity of conductors

b) Resistance of Earthing conductor
c) Continuity of ring circuits Earth fault loop impedance at main switch
d) Elevated voltage on supply neutral Earth Resistance
e) Insulation resistance
f) Voltage, main distribution board - no load
g) Voltage, main distribution board - on load
h) Voltage at available load
i) Operation of earth leakage units
j) Earth leakage test button
k) Polarity at points of consumption
l) Switching devices

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Engineering Standard

MV & LV Earthing

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1. SCOPE

1.1 Application

1.1.1 This Standard Specification covers the materials, components and installation requirements for earthing systems of industrial medium- and low voltage electrical installations.

1.1.2 General standard requirements are dealt with in this specification, and the project-specific requirements are dealt with in the Project Specification.

1.1.3 This standard specification covers protective earthing and bonding, but not functional earthing and bonding which shall be provided in accordance with the specifications of electrical and electronic equipment suppliers.

1.1.4 This standard specification does not cover electromagnetic compatibility (EMC) earthing and bonding, which shall be provided as specified in the Project Specification if required.

1.1.5 Whilst this specification covers earth termination systems for a building lightning protection system (LPS), it does not cover the LPS itself and surge protection for equipment.

1.1.6 The following does not fall within the scope of this standard specification:

a) The earthing of outdoor open-terminal MV substations.

b) The earthing of electronic systems and equipment.

1.2 General Requirements

1.2.1 The completed earthing systems shall incorporate all materials and components necessary to provide the required protective earthing and bonding.

1.2.2 All materials and components shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification contains standard amendments and requirements, which shall be applied to the referenced statutory and national standards. The project-specific requirements are provided in the Project Specification, which shall be read in conjunction with this Specification.

2.1.2 The design, construction, installation, inspection, testing and commissioning of the earthing systems shall comply with all relevant statutory regulations, and the latest editions (current at the time of tender) of all relevant South African National Standards.

2.2 Statutory Requirements

2.2.1 The earthing systems shall comply with the following:

a) Occupational Health and Safety Act of 1993 and Regulations

b) SANS 10142-1 The Wiring of Premises Part 1: Low-voltage Installations

c) SANS 10142-2 The Wiring of Premises Part 2: Medium-voltage Installations

2.3 Reference Standards

2.3.1 The following national standards shall be complied with as applicable:

Table 1: Reference Standards

Standard Number	Description
SANS 1063	Earth rods, couplers and connections
SANS 1411-1	Materials of insulated electric cables and flexible cords - Part 1: Conductors
SANS 10198-3	Power cables up to 33 kV: Earthing systems - General provisions
SANS 10198-12	Power cables up to 33 kV: Installation of earthing system
SANS 10199	The design and installation of earth electrodes
SANS 10200	Neutral earthing in medium-voltage industrial power systems
SANS 10292	Earthing of low-voltage distribution systems
SANS 62305-3	Protection against lightning: Physical damage to structures and life hazard

3. EARTHING OF TRANSFORMER AND GENERATOR NEUTRALS

3.1 Distribution Transformers

3.1.1 The neutrals of distribution transformers shall be either solidly- (directly) or resistively earthed as specified in the Project Specification.

3.1.2 Unless otherwise specified in the Project Specification, the earthing connection shall be made with 70 mm² bare copper earth conductor to the installation's main earthing bar(s) or to dedicated combined MV and LV earth electrodes in the case of remotely installed transformers or mini-subs (refer Clauses 6.2 and 6.3).

3.1.3 Where artificial neutrals are required for transformers with delta-connected secondary windings, neutral electromagnetic couplers /neutral earthing compensators (NECs) shall be provided as specified in the Project Specification.

3.1.4 Where neutral earthing resistors (NERs) are required to limit earth fault current, they shall be provided as specified in the Project Specification, either as separate units or in combination with NECs (and referred to as NECRs).

3.2 Standby Generators

3.2.1 LV standby generators shall be earthed in accordance with SANS 10142-1: The Wiring of Premises Part 1: Low-voltage Installations unless otherwise specified in the Project Specification.

3.2.2 The neutrals of MV standby generators shall be resistively earthed with NERs dedicated to the individual generators unless otherwise specified in the Project Specification.

3.2.3 Unless otherwise specified in the Project Specification, the earthing connection shall be made with 70 mm² bare copper earth conductor via the installation's main earthing bar(s).

4. EARTH ELECTRODES

4.1 General

4.1.1 Earth electrodes shall be provided as specified in the Project Specification for power systems, electrical equipment and LPS earthing.

4.1.2 The earth electrodes shall be constructed in accordance with Sub-clauses 4.2 to 4.8 of this specification as relevant.

4.1.3 Earth electrodes shall be tested in accordance with Clause 9 of this specification and shall be extended as directed by the Engineer in writing if required to achieve a lower earth resistance.

4.2 Earth Grids

4.2.1 Earth grids for electrical equipment yards shall be constructed in the form of a large rectangular arrangement of conductors buried in trenches and divided by longitudinal and transverse conductors into a number of smaller rectangles having mesh dimensions as specified in the Project Specification.

4.2.2 The horizontal conductors shall be high-conductivity, annealed, stranded copper conductors with a cross-sectional area of 70 mm^2 unless otherwise specified in the Project Specification.

4.2.3 Where horizontal conductors cross each other they shall be joined by exothermic welding or oxy-actylene brazing.

4.2.4 Horizontal conductors shall be buried directly in the ground at 500 mm below finished ground level (unless otherwise specified in the Project Specification), before any stone layer is put down, in 300 mm wide excavated trenches which shall be backfilled in well-compacted layers.

4.2.5 Supplementary earth rods shall be provided as specified in the Project Specification and shall comply with Clause 4.8 of the specification.

4.3 Ring and Foundation Earth Electrodes

4.3.1 A foundation earth electrode shall comprise a continuous length of bare copper earth conductor installed under the perimeter concrete foundation of a building, with the ends brought out to the main earthing bar to form a closed loop. The conductor shall be fixed to the top of the blinding layer just before the concrete foundation is poured to avoid theft of the conductor.

4.3.2 At each corner of the building a 2 m conductor tail shall be exothermically welded to the foundation earth electrode and buried in an accessible location to allow the electrode to be extended if required.

4.3.3 Supplementary earth rods shall be provided as specified in the Project Specification and shall comply with Clause 4.8 of the specification.

4.3.4 A ring earth electrode shall be similar to a foundation earth electrode, except that it shall be external to the structure and in contact with soil for at least 80 % of its total length. Unless otherwise specified in the Project Specification, the ring earth electrode shall be installed 500 mm below finished ground level and 1000 mm from external walls. Ring earth electrodes shall only be provided in place of specified foundation earth electrodes with the Engineer's written approval.

4.3.5 Horizontal conductors shall be as specified for earth grids in Clause 4.2.2 of this specification.

4.4 Array of Rods

4.4.1 An array of rods interconnected with horizontal conductor in the form of a "T" shall be constructed with horizontal conductor lengths and rod quantities and lengths as specified in the Project Specification to achieve the required earth resistance.

4.4.2 The horizontal conductor shall comply with Clause 4.2.2 of this specification.

4.4.3 The earth rods shall comply with Clause 4.8 of this specification.

4.4.4 The horizontal conductor and the tops of the earth rods shall be 500 mm below finished ground level.

4.5 Trench Electrodes (Cable-route Earth Electrodes)

4.5.1 Trench earth electrodes shall comprise buried horizontal conductor and supplementary earth rods installed in a linear arrangement in MV/LV cable trenches.

4.5.2 The conductor lengths and rod quantities and lengths shall be as specified in the Project Specification to achieve the required earth resistance.

4.5.3 The horizontal conductor shall comply with Clause 4.2.2 of this specification.

4.5.4 The earth rods shall comply with Clause 4.8 of this specification.

4.6 Earth Termination Systems for Lightning Protection

4.6.1 Earth termination systems (ETSs) for lightning protection systems (LPSs) for structures shall be either Type A or Type B arrangements (defined in SANS 62305-3) as specified in the Project Specification.

4.6.2 Ring- and foundation earth electrodes as specified in Clause 4.3 of this specification meet the requirements for Type B arrangements and shall be provided where called for in the Project Specification.

4.6.3 Type A arrangements shall comprise horizontal and/or vertical electrodes (i.e. conductors and/or rods) installed outside the structure to be protected, connected to down conductors, and not forming a closed loop. The required arrangement for a particular structure shall be as specified in the Project Specification.

4.7 Earth Mats

4.7.1 Earth mats shall be provided as called for in the Project Specification where required to provide an extra protective measure to minimize the danger of exposure to high step or touch potentials for operators of outdoor electrical equipment.

4.7.2 Earth mats shall be constructed out of 70 mm² bare copper conductor in the form of a grid with outer dimension 1500 mm x 1500 mm and with longitudinal and transverse conductors spaced 100 mm apart. Crossovers shall be exothermically welded.

4.7.3 Earth mats shall be buried 500 mm below finished ground level.

4.8 Earth Rods

4.8.1 Earth rods used for the earthing system shall be of the "A" grade and shall have a 250 micron copper jacket. Unless otherwise specified in the Project Specification, the rods shall comply with the following:

a) The earth rods shall be extendible, copper clad, high tensile steel (500 MPa) rods and shall bear the SABS mark of approval. They shall be at least 16mm in diameter and shall have hardened steel tips with driving caps.

b) Individual rods shall not have a length of more than 1.5 m.

c) Connections between individual rods shall be by screwed joints in accordance with one of the following:

   i) The ends of the rods shall be externally threaded and be joined by a counter bored, threaded coupler designed to completely enclose the threaded section of the rod. The external threads shall be roll-formed with a minimum copper coating thickness of 0,05 mm at the root of the threads. Couplers shall be manufactured from high strength silicon or aluminium bronze; or

   ii) The ends of the rods shall be internally threaded and joined by a screwed phosphor bronze dowel. A corrosion inhibiting paste shall be applied to the threads before assembly.

d) A single earth rod assembly shall be not more than 6 m long and the separation between adjacent earth rod positions shall be not less than 1,25 times the length of the longest earth rod assembly.

e) The absence of any buried services, down to the maximum driving depth, shall be established before rods are driven into the ground.

5. EARTHING BARS AND CONDUCTORS

5.1 Earthing Bars

5.1.1 A main earthing bar shall be provided in every MV switchroom or in the main LV switchroom for installations with an LV bulk electricity supply. Supplementary earthing bars shall be provided in other electrical rooms as specified in the Project Specification.

5.1.2 All earthing bars connected to earth electrodes shall have one disconnecting terminal to allow for testing of the associated earth electrodes and shall be constructed in accordance with Standard Drawing for Earthing Bar (Figure 1).

5.1.3 Unless otherwise specified in the Project Specification, earthing bars shall be mounted on the side walls of cable trenches in the positions indicated on the layout drawings.

5.1.4 The earthing bar arrangement shall be as per the following detail sketch:

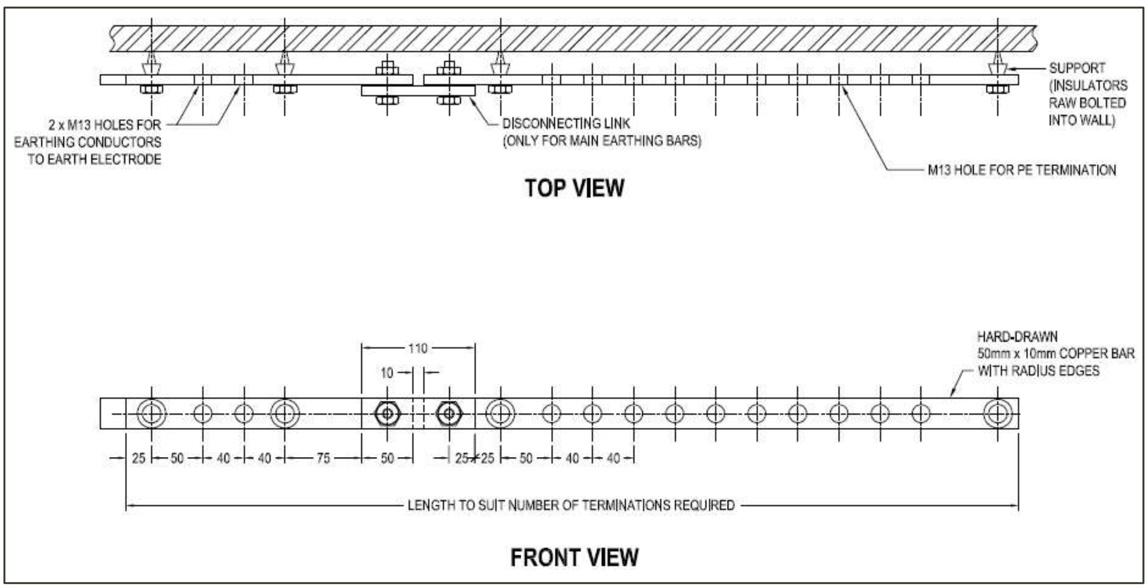


Figure 1: Earthing Bar

5.2 Earthing-, Parallel Earthing-, and Earth Continuity Conductors

5.2.1 Earthing conductors shall be provided to link earthing bars to earth electrodes, except where the conductor ends of ring- and foundation earth electrodes are terminated at the earth bars. Earthing conductors shall be bare 70 mm² annealed stranded copper conductors, unless otherwise specified in the Project Specification.

5.2.2 Parallel earthing conductors shall be provided as specified in the Project Specification to provide a low impedance connection between separate earthing arrangements. Unless otherwise specified, the conductors shall be laid along cable routes, and shall be bare 70 mm² annealed stranded copper conductors.

5.2.3 Earth continuity conductors (ECCs) shall be provided:

a) With supply cables to MV switchgear and to LV Assemblies

b) To earth the exposed conductive parts of all electrical equipment in accordance with SANS 10142: The Wiring of Premises.

5.2.4 ECCs for MV equipment shall be connected from the MV earthing bar and ECCs for LV equipment shall be connected from the earthing bars in the LV Assemblies from which the equipment receives supply.

5.2.5 ECCs shall be separate conductors or shall form part of the equipment supply cables as specified in the Project Specification. ECCs which does not form part of a cable shall be annealed copper stranded conductors of the specified cross-sectional area and shall be either bare or PVC-insulated as specified in the Project Specification.

6. EARTHING OF MV AND LV EQUIPMENT AND ELECTRICAL YARD FENCES

6.1 MV Switchgear

6.1.1 The earthing bars of MV switchgear shall be connected to the main earthing bar by means of two 70 mm² bare copper earth conductors, unless otherwise specified in the Project Specification. These protective earthing conductors shall be taken from opposite ends of the switchgear earthing bars.

6.1.2 For ring main units (RMUs) in mini-subs, the RMU and cable termination enclosure earthing bars shall be bonded to the mini-sub's MV earth bar and to each other in accordance with SANS 1874: Metal-enclosed ring main units.

6.1.3 For RMUs in outdoor steel kiosks, the steel enclosure shall be bonded to the RMU earth bar with 70 mm² bare copper earth conductor.

6.2 Distribution Transformers

6.2.1 Outdoor ground-mounted distribution transformers shall be provided with an equipotential earth electrode in accordance with the Standard Drawing for Distribution Transformer Earthing (Figure 2).

6.2.2 Unless otherwise specified in the Project Specification, the transformer tank earthing terminal shall be separately connected to the closest indoor main earthing bar with a 70 mm² bare copper earth conductor.

6.2.3 Unless otherwise specified in the Project specification, remotely-installed transformers (i.e. which are not installed close to indoor main earthing bars) shall be provided with dedicated combined MV- and LV earth electrodes in accordance with the Standard Drawing for Distribution Transformer Earthing (Figure 2).

6.2.4 Transformer LV neutrals shall be bonded to the earthing terminal in the LV terminal box.

6.2.5 Distribution transformers shall be earthed and bonded in accordance with the Standard Drawing for Distribution Transformer Earthing (Figure 2):

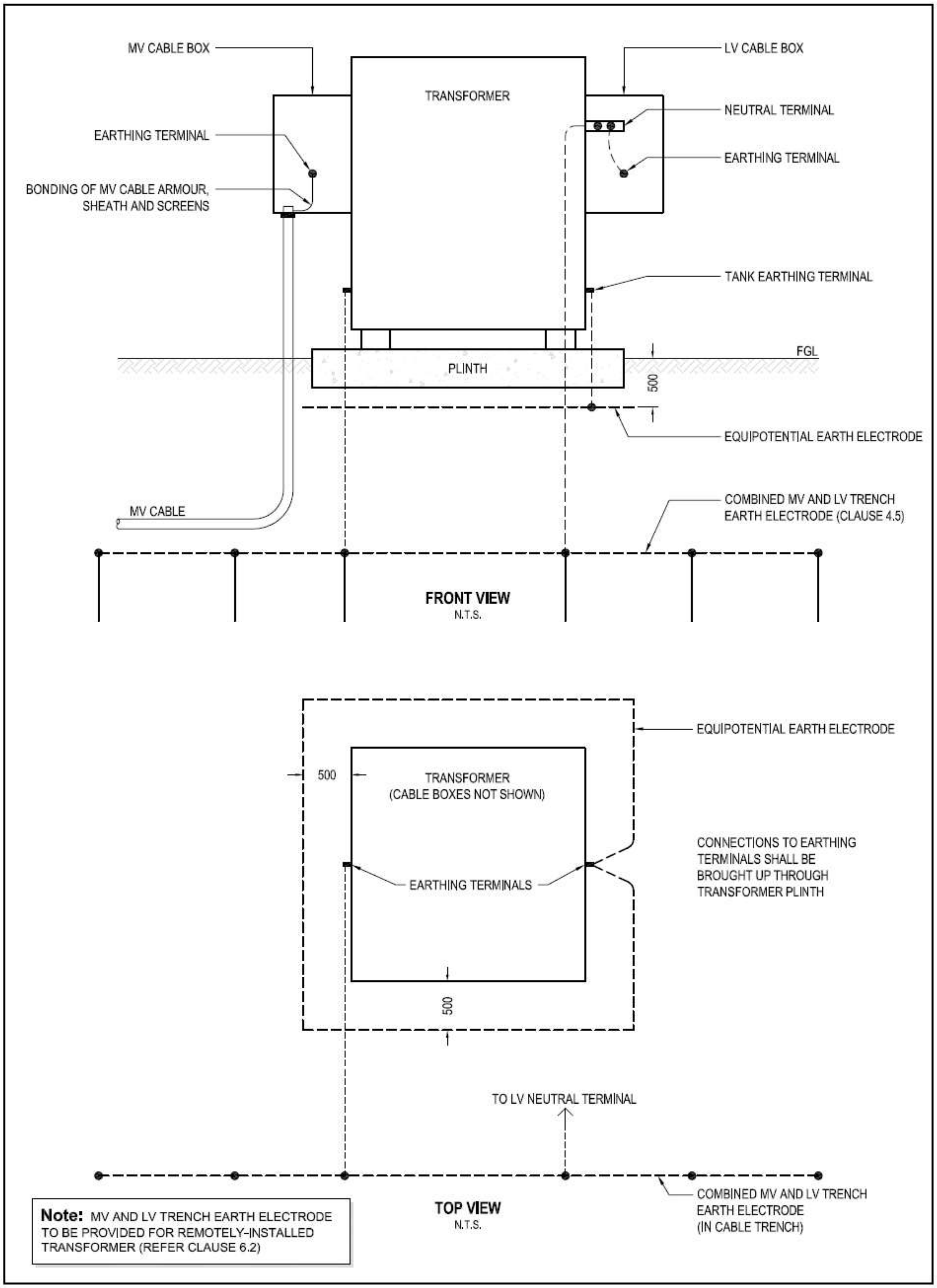
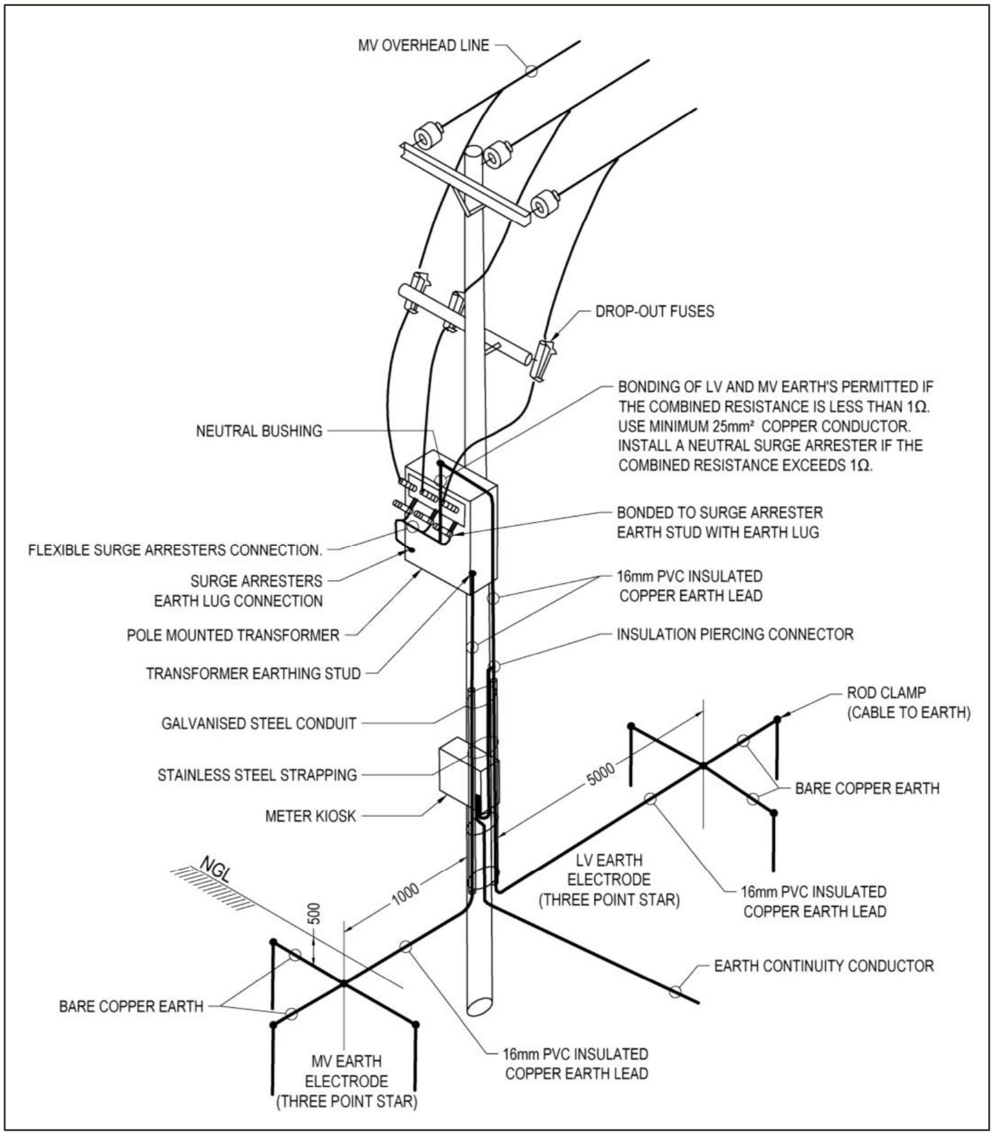


Figure 2: Distribution Transformer Earthing

6.2.6 Pole-mounted transformers shall be earthed in accordance with the Standard Drawing for Pole-Mounted Transformer Earthing (Figure 3):



NOTES

1. THE STEELWORK, TRANSFORMER TANK AND MV SURGE ARRESTORS ARE TO BE BONDED AND CONNECTED TO THE MV EARTH ELECTRODE.
2. THE TRANSFORMER NEUTRAL, LV SURGE ARRESTORS AND TRANSFORMER METERING BOX ARE TO BE BONDED AND CONNECTED TO THE LV EARTH ELECTRODE.
3. THE EARTHING CONTINUITY CONDUCTOR (ECC) SHOULD NOT BE SMALLER THAN HALF THE CROSS SECTIONAL AREA OF THE LARGEST CURRENT CARRYING CONDUCTOR OF THE SUPPLY CABLE.
4. A MINIMUM SEPARATION DISTANCE OF 5000mm IS TO BE MAINTAINED BETWEEN THE MV & LV EARTH ELECTRODES.
5. EARTH ELECTRODES SHALL BE COMBINED IF RESISTANCE IS LESS THAN OR EQUAL TO 1Ω.

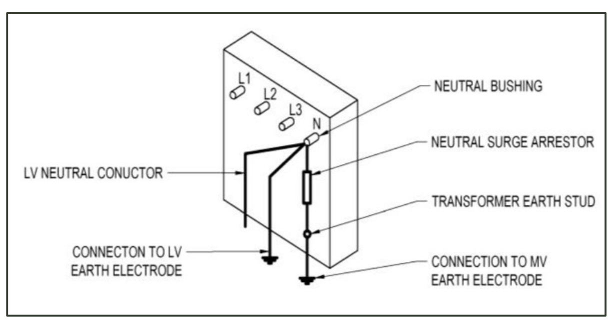


Figure 3: Earthing at MV/LV transformer pole mounted transformer

6.3 Miniature Substations (Mini-subs)

6.3.1 Mini-subs shall be provided with an equipotential earth electrode in accordance with Figure 4.

6.3.2 Unless otherwise specified in the Project Specification, the mini-sub MV earth bar shall be separately connected to the closest indoor main earthing bar with a 70 mm^2 bare copper earth conductor.

6.3.3 The internal earthing arrangement of mini-subs shall be in accordance with SANS 1029: Miniature Substations as applicable to combined MV- and LV earth electrodes.

6.3.4 Unless otherwise specified in the Project Specification, remotely-installed mini-subs (i.e. which are not installed close to indoor main earthing bars) shall be provided with a combined MV- and LV earth electrode, to which the mini-sub MV earth bar shall be connected, in accordance with Figure 4.

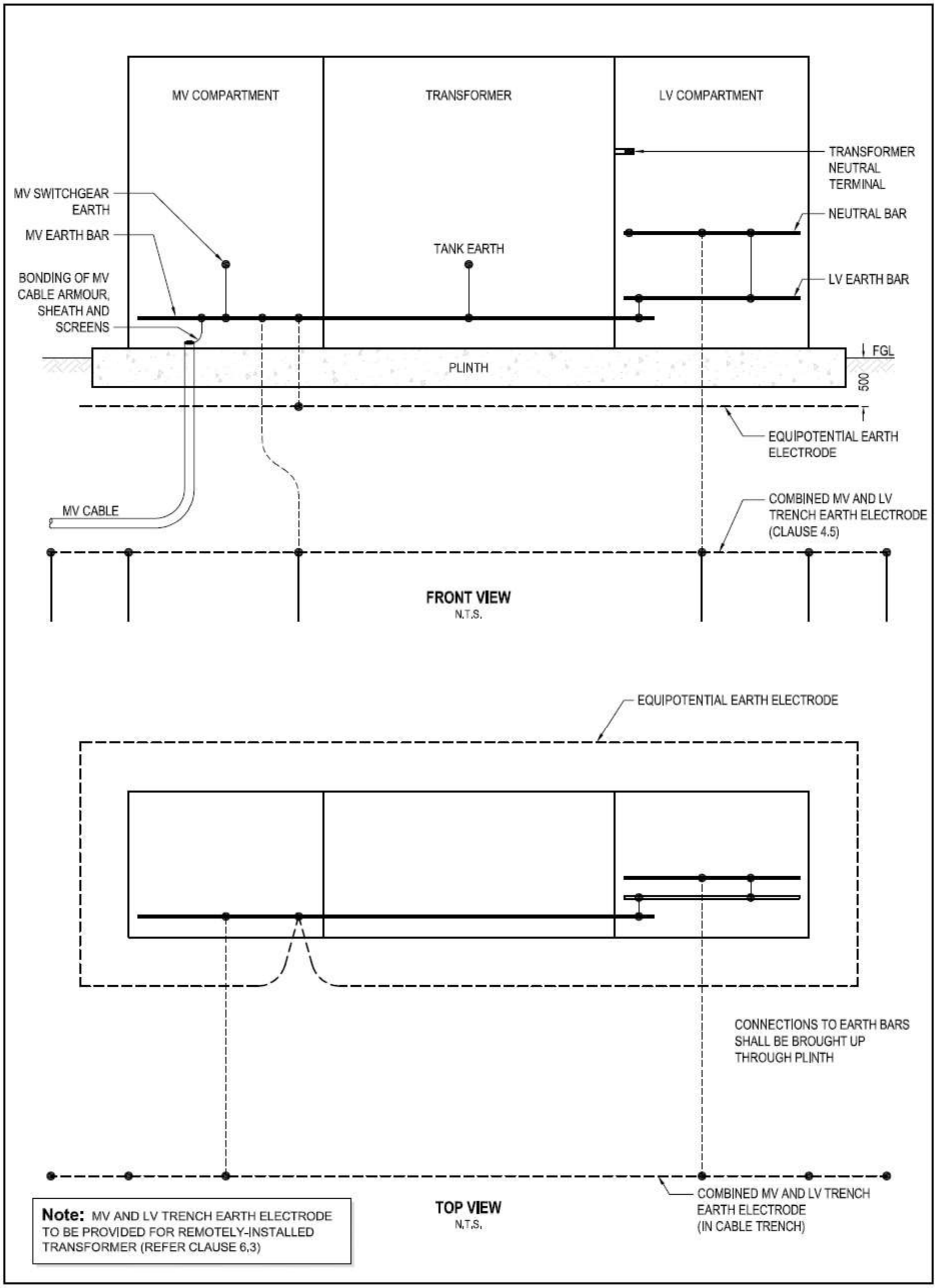


Figure 4: Mini Sub Earthing

6.4 Motors

6.4.1 Where the protective earth conductor forms part of the supply cable to an LV motor, it shall be connected to the earth terminal inside the motor terminal box.

6.4.2 Separate protective earthing conductors shall be connected to the external frame earth terminal of a motor and a jumper shall be provided from the frame terminal to the motor's terminal box. The jumper shall be crimped to the protective earth conductor and not separately bolted to the frame terminal.

6.4.3 Separate protective earthing conductors shall be PVC-insulated copper conductors with cross-sectional areas as specified in the Project Specification.

6.4.4 Earthing connections to converter-fed motors shall be in accordance with the Standard Drawing for Converter-Fed Motor Earthing.

6.5 PFC Capacitor Banks and Harmonic Filters

6.5.1 The capacitor casings and metal support frames of free-standing PFC capacitor banks shall be earthed in accordance with the supplier's installation instructions.

6.5.2 The support base/insulators of free-standing air-cored reactors shall be earthed in accordance with the supplier's installation instructions, with care being taken to not create closed loops within which currents can be induced.

6.5.3 Free-standing iron-cored reactors and filter resistors shall be earthed in accordance with the supplier's installation instructions.

6.5.4 Where equipment is installed indoors, the earthing connections shall be made with copper earthing continuity conductors to the main earthing bar.

6.5.5 Where the equipment is installed outdoors in a fenced yard, the earthing connections shall be made to the earth grid of the yard.

6.6 MV and LV Cables

6.6.1 The metal components of cables shall be earthed in accordance with the following standards:

Table 2: MV and LV Cable earthing standards

Standard Number	Description
SANS 10142-1	The Wiring of Premises Part 1: Low-voltage Installations
SANS 10198-9	Power Cables Up To 33 kV: Jointing and Termination of Extruded Solid Dielectric-Insulated Cables up to 3,3 kV
SANS 10198-10	Power Cables Up To 33 kV: Jointing and Termination of Paper-Insulated Cables
SANS 10198-11	Power Cables Up To 33 kV: Jointing and Termination of Screened Polymeric-Insulated Cables
SANS 10198-12	Power Cables Up To 33 kV: Installation of Earthing System

6.6.2 Unless otherwise specified in the Project Specification, metal sheaths, metal screens and armouring of single-core cables shall be earthed at both ends of the cables.

6.6.3 Unless otherwise specified in the Project Specification, metal sheaths, metal screens and armouring of single-core cables shall be earthed at both ends of the cables.

6.7 MV Surge Arresters

6.7.1 Surge arresters at MV overhead line supply points shall be earthed in accordance with the Standard Drawing for OHL Surge Arrester Earthing.

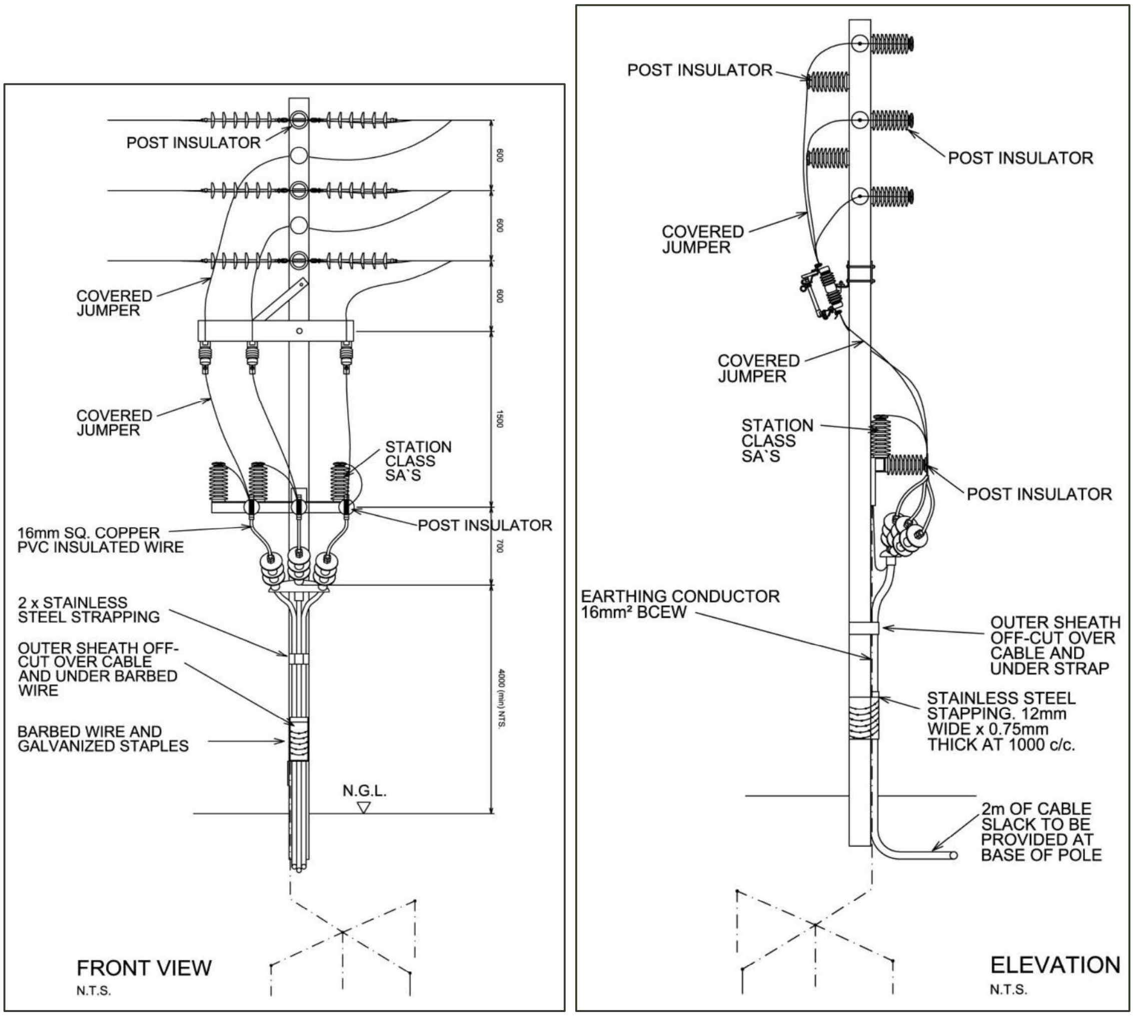


Figure 5: Earthing of MV Overhead Surge Arresters

6.8 Equipment Yard Fences

6.8.1 The enclosing fences of outdoor equipment yards for electrical equipment (switchgear, transformers, PFC capacitors, harmonic filters, etc.) shall be earthed in accordance with the Standard Drawing for Equipment Yard Fence Earthing.

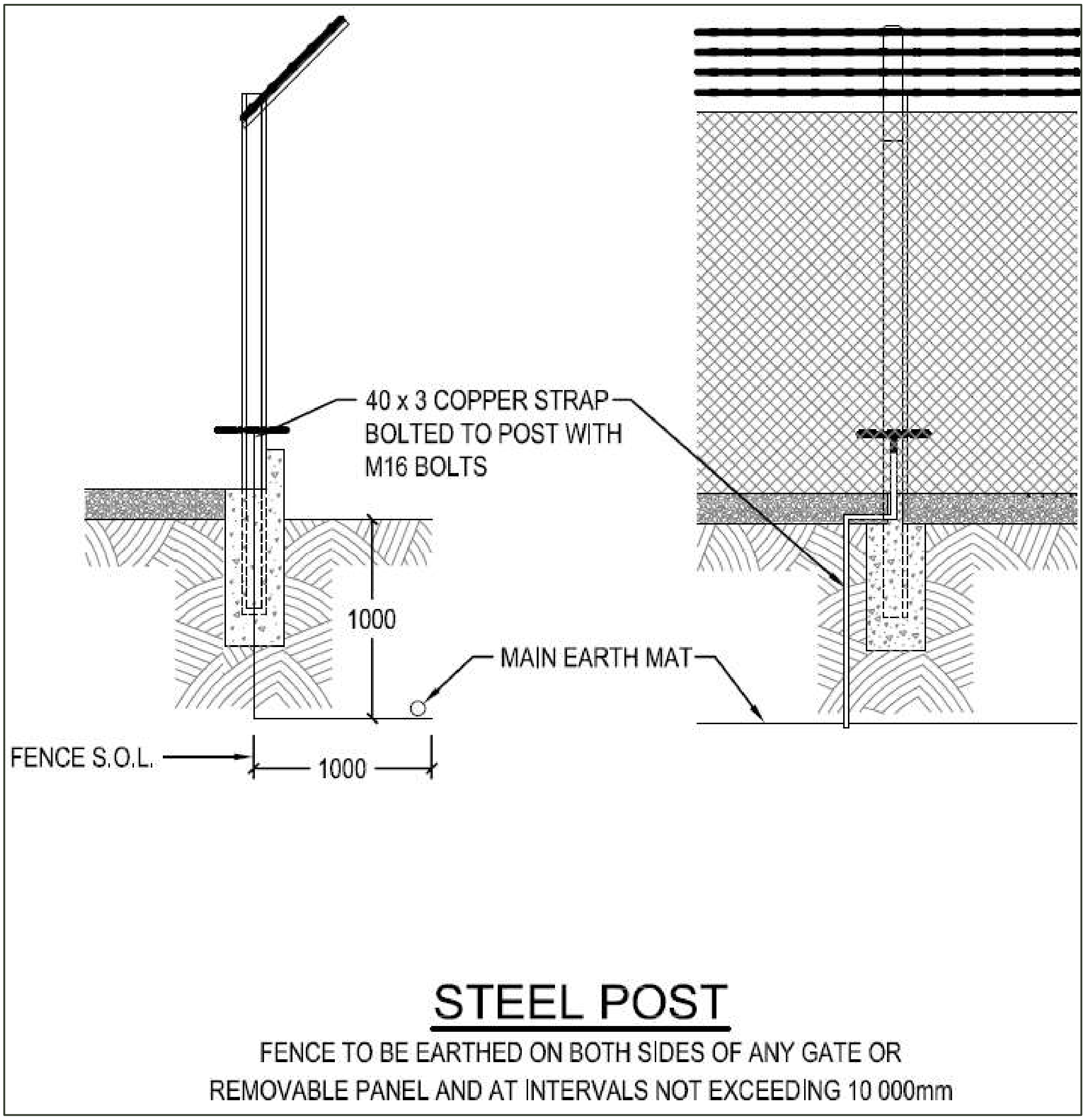
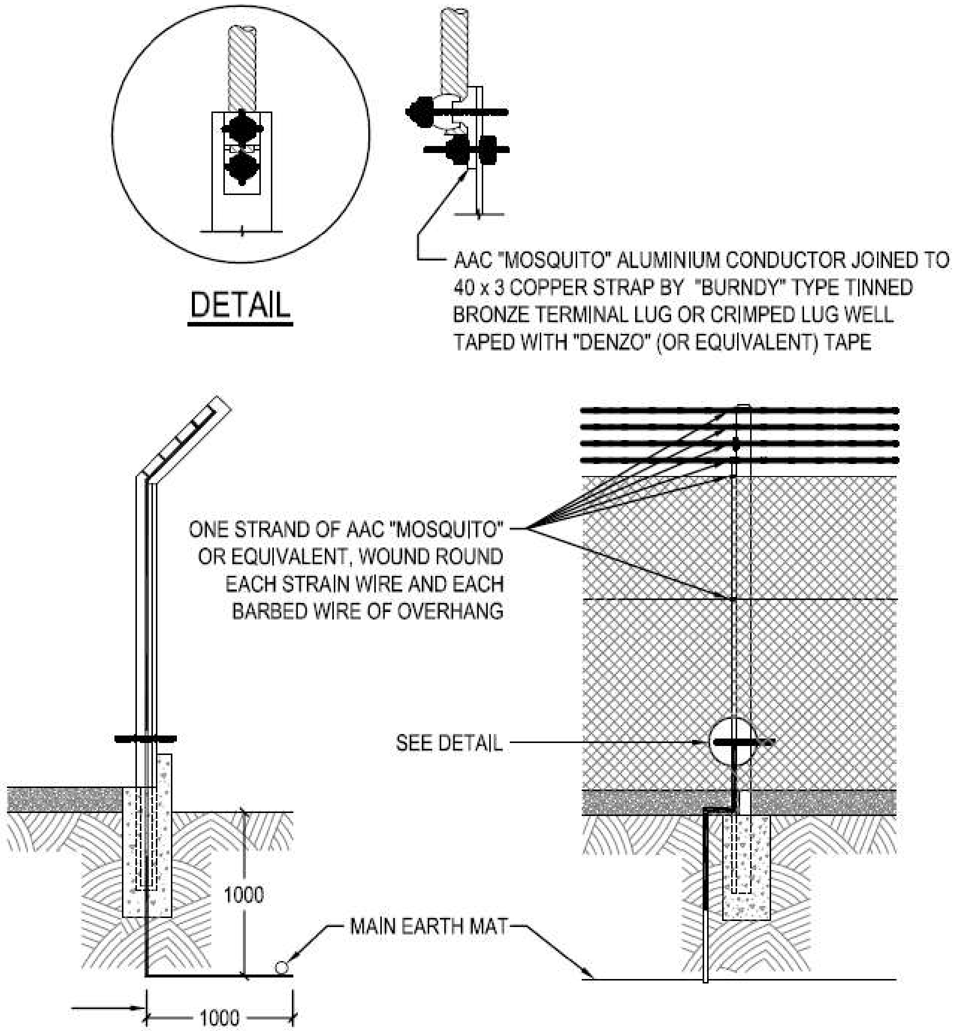


Figure 6: Earthing of Equipment Yard Fences



CONCRETE POSTS WITH ALUMINIUM WIRE FENCE

FENCE TO BE EARTHED ON BOTH SIDES OF ANY GATE OR REMOVABLE PANEL AND AT INTERVALS NOT EXCEEDING 10 000mm

6.9 LV Electrical Equipment

6.9.1 LV electrical equipment shall be earthed in accordance with SANS 10142-1: The Wiring of Premises Part 1: Low-voltage Installations.

7. EQUIPOTENTIAL BONDING

7.1 Main Equipotential Bonding

7.1.1 Main equipotential bonding shall be provided in accordance with SANS 10142-1 from the main earth bar to the following extraneous conductive parts of an installation:

a) Hot and cold water systems

b) Antennas

c) Other services in conductive material

7.1.2 Main equipotential bonding conductors to the above shall be bare copper earth conductors with a cross-sectional areas as follows:

a) Water systems: 0,5 x installation earthing conductor (6 mm² min to 25 mm² max)

b) Antennas: 2,5 mm²

c) Other services: 2,5 mm²

7.2 Supplementary Equipotential Bonding

7.2.1 Mandatory supplementary equipotential bonding shall be provided in accordance with SANS 10142-1.

7.2.2 Supplementary equipotential bonding shall be provided between exposed conductive parts of the installation where these parts are 2,5 m or less apart. The bonding conductor shall be bare copper earth conductor and shall not be smaller than the smaller of the two earth continuity conductors to the items of equipment.

7.2.3 Supplementary equipotential bonding shall be provided between exposed conductive parts and extraneous conductive parts where these are 2,5 m or less apart. The bonding conductor shall be bare copper earth conductor and shall be at least equal to the half the size of earth continuity conductor to the electrical item of equipment.

7.2.4 Bonding conductors shall be connected to equipotential bonding terminals on equipment/devices or, if these are not provided, shall be bolted to the equipment/devices to the approval of the Engineer.

7.3 Bonding of Wireways

7.3.1 A 70 mm² bare copper earth conductor shall be installed along each cable ladder/tray and each third section shall be bonded to the earth conductor with 35 mm² bare copper earth bonding conductors and purpose-made earth clips. At least one end, but where practicable both ends, of the earth conductor shall be connected to the main earthing bar.

7.3.2 Rigid metal conduiting shall be bonded in accordance with SANS 10142-1.

8. NECR AND NER

8.1 Neutral Electromagnetic Coupler/Resistor Combinations

8.1.1 Neutral electromagnetic couplers (NECs), also referred to as neutral earthing compensators, shall be provided as specified in the Project Specification to create artificial MV supply/transformer neutral points for earthing via a neutral earthing resistor (NER). The NEC and NER shall be a combined unit, referred to as an NECR.

8.1.2 NECRs shall comply with Aurecon Engineering Standard SPE-EP-0024: Neutral Electromagnetic Couplers (NEC) with NERs and Auxilliary Transformers.

8.2 Neutral Earthing Resistors

8.2.1 Standalone NERs shall be provided as specified in the Project Specification for resistive earthing of the neutrals of star-connected transformer secondary windings and MV generator windings.

8.2.2 NERs shall comply with Aurecon Engineering Standard SPE-EP-0024: Neutral Electromagnetic Couplers (NEC) with NERs and Auxilliary Transformers.

9. TESTING

9.1 Soil Resistivity Survey

9.1.1 A soil resistivity survey shall be carried out in accordance with SANS 10199 if specified in the Project Specification.

9.1.2 The Wenner method of measurement shall be followed unless soil depths of greater than 20 m are to be investigated.

9.1.3 The survey shall be carried out in the area where the earth electrode will be installed and readings shall be taken in at least two different directions. Unless earth rods are to be installed to greater depths than 12 m, measurements shall be taken with at least the following electrode spacings: 1/2/3/5/10/15 m.

9.1.4 The results of the survey shall be submitted to the Engineer in the form of a table showing soil resistivity in ohm.metres for the various depths of measurement, as well as in the form of a graph. If the graph shows a significant variation in soil resistivity with depth, then a two layer soil model shall be constructed.

9.2 Earth Electrode Resistance Measurement

9.2.1 The earth resistance of an earth electrode shall be measured in accordance with SANS 10199.

9.2.2 The resistance curve and the calculated earth electrode resistance shall be submitted to the Engineer who will issue a written instruction if it is necessary to extend the earth electrode to lower its resistance.

9.3 Earth Surface Potential Measurement

9.3.1 Where called for in the Project specification earth surface potential measurements shall be made by measuring touch- and step potential contact resistance at specified outdoor equipment.

9.3.2 The proposed measurement method shall be approved by the Engineer and resistance readings shall be submitted to the Engineer for the calculation of touch- and step potentials.

9.4 Earth Continuity and Bonding

9.4.1 Earth continuity and bonding tests shall be carried out in accordance with SANS 10142: The Wiring of Premises Parts 1 & 2.

10. DOCUMENTATION AND TRAINING

10.1 General

10.1.1 All Assembly drawings, documentation and reports shall be in English, and each item shall be identified with:

a) Employer's name and contact details

b) Employer's contract reference title and numbers

c) Engineer's name and contact details

d) Engineer's reference numbers

e) Contractor's works / contract / order references

f) Contractor's name and contact details

10.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

10.2 Drawings for Acceptance by the Engineer

10.2.1 Where alternative earthing arrangement designs to those specified are proposed by the Contractor, drawings shall be submitted to the Engineer for his acceptance before construction commences.

10.3 Testing Documentation and Reports

10.3.1 Test reports for soil resistivity tests shall contain the following:

a) Methodology statement

b) Measurement results in tabulated form

c) Measurement results in graphic form

d) Overlay of measured graph on master graph as per SANS 10199

e) Calculated resistivity results for two layer model

10.3.2 Test reports for earth resistance tests shall contain the following:

a) Methodology statement

b) Measurement results in tabulated form

c) Measurement results in graphic form

d) Calculated resistance value for earth electrode under test

10.4 Operating and Maintenance Manual

10.4.1 As-built drawings and all test reports shall be included in the Operating and Maintenance Manual which must be provided under the Contract.

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Engineering Standard

Electrical Valve Actuators

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Contents

Tables

1. SCOPE

1.1 Application

1.1.1 This document specifies the standard requirements for the performance, design, construction, installation, testing and commissioning of electric actuators used to automate valves, penstocks, weirs, etc.

1.1.2 The primary intention of this Specification is to ensure the provision of an electrical installation which has been properly designed and constructed to ensure safe reliable operation and to facilitate safe inspection, test and maintenance.

1.2 General

1.2.1 The completed installation shall incorporate all components and equipment necessary to reliably achieve the functionality defined in the Particular Specification / Technical Data Sheets / this Specification under all foreseeable conditions; whether or not they have been explicitly detailed, to provide the end user of the installation or the end user's nominated representative (hereafter referred to as the Employer) with a fully working installation.

1.2.2 All materials, components, and equipment used for the installation of electric valve actuators shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.

1.2.3 Equipment with replaceable spare parts shall be available for a purchase period of five (5) years from the date of acceptance of the system.

1.2.4 For complete definition of requirements, this Specification must be read in conjunction with the Scope of Works, the Particular Specification and Technical Data Sheets associated with the respective material requisition documentation.

1.3 Installation Performance Requirements

1.3.1 The installation shall be suitable for its intended duty with respect to the electrical supply, distribution, and load requirements.

1.3.2 The installation shall be suitable for the environmental conditions, particularly with respect to corrosion resistance and ingress protection.

1.3.3 The installation shall be suitable for its intended location, particularly with respect to the mechanical properties and impact strength of the components parts.

1.3.4 The installation shall be compatible with new or existing equipment, pumps, penstocks, sluice gates, valves and data communications network.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detail specification of the project or site specific requirements will be found in the Particular Specification / Specification Data and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.

2.1.2 The design, construction, installation, inspection, testing and commissioning of the Installation shall comply with all relevant Statutory Regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.

2.1.3 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.

2.1.4 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the installation.

2.2 Regulations, Specifications and Standards

2.2.1 The design, construction, inspection and testing of the Installation shall comply with all relevant Statutory Regulations and Directives including:

a) Occupational Health and Safety Act (Act 85 of 1993)

b) Regulations of the Local Supply Authority

2.2.2 All electric valve actuators shall be provided in accordance with current best practice and all applicable statutory and recognised requirements and standards, and shall be constructed and assembled with a high level of skill and craftsmanship.

2.2.3 The entire works shall be carried out in accordance with the requirements of all the relevant Government Acts and Regulations

2.3 Recognised Standards

2.3.1 The latest edition, including all amendments up to date of tender of the following particular national and international specification, publications and codes of practice shall be read in conjunction with this specification and shall be deemed to form part thereof:

Table 1: Reference Standards

Standard Number	Description
SANS 664	Cast iron gate valves for water works
SANS 1123	Steel pipe flanges
SANS 1804	Induction motors
SANS 10083	The measurement and assessment of occupational noise for hearing conservation purposes
SANS 10108	The classification of hazardous locations and the selection of apparatus for use in such locations
SANS 10142	Standard Regulations for Wiring of Premises
SANS 60034	Rotating Electrical Machines
SANS 60204	Safety of machinery. Electrical equipment of machines.
SANS 60529	Degrees of protection provided by enclosures (IP Code)

Standard Number	Description
SANS 60730-2-14	Automatic electrical controls for household and similar use: Particular requirements for electric actuators
SANS 60947-7	Specification for low-voltage switchgear and controlgear. Ancillary equipment.
SANS 61010	Safety requirements for electrical equipment for measurement, control, and laboratory
Other Standards	**Description**
BS 4999	General requirements for rotating electrical machines
BS EN ISO 5210	Industrial valves. Multi-turn valve actuator attachments
BS EN ISO 5211	Industrial valves. Part-turn valve actuator attachments.
BS EN 12570	Industrial valves. Method for sizing the operating element
BS EN 60085	Electrical insulation. Thermal evaluation and designation

3. GENERAL REQUIREMENTS

3.1 General

3.1.1 The actuator shall typically incorporate an electric motor, integral reduction gearing, reversing motor starter, local controls, torque and position limit devices and contacts for remote control and monitoring, all housed in a sealed enclosure.

3.1.2 The actuator shall provide the means for local and remote valve operation and shall also provide a means of manual valve operation (handwheel) during electric power interruption. The local/remote-control selection switch shall be designed with a locking device to inhibit unauthorized adjustments being made to the valve settings.

3.1.3 The Contractor shall provide the first fill of lubricants to all components/systems requiring lubrication.

3.1.4 Actuators shall be capable of being mounted and operated in any vertical/horizontal inclination.

3.1.5 The actuator shall be delivered with suitable protection against damage and ingress of moisture, whilst in temporary storage, without an electricity supply.

3.2 Preference of Manufacturer

3.2.1 All Actuators shall be standard catalogue models and shall be readily available.

3.2.2 All actuators shall, where possible, be from the same manufacturer and shall have the same interchangeable frames. Variations in type and size shall, where possible, be limited to prevent stocking a variety of special spares.

3.2.3 Equipment which has not previously been in common use in South Africa shall not be acceptable unless specifically called for in the Particular Specification or unless the Engineer agrees in writing.

3.3 Electrical Supply Characteristics

3.3.1 Unless otherwise specified on the Technical Data Sheets, the actuator shall be suitable for a 380/400/415 V, three phase, three wire, earthed neutral, 50 Hz supply.

3.3.2 The actuators shall be capable of operating within ± 10 % of the nominal supply voltage without risk of damage. All actuators shall be suitable for operating continuously under actual service conditions, including the ± 10 % voltage tolerance.

3.3.3 The actuator shall be capable of operating under conditions of three (3) phase supply imbalance, where the negative and zero phase sequence components of the voltage do not individually exceed 2 % of the positive phase sequence components.

3.3.4 All actuators shall be capable of operating continuously under actual service conditions at any supply frequency between 48 and 51 Hz.

3.3.5 The actuator shall be designed to remain in position without damage upon failure of the electrical supply.

3.4 Weight

3.4.1 The weight of the actuator and the heaviest individual maintenance and erection lifts shall be as stated on the Technical Data Sheets.

3.5 Mounting Arrangements

3.5.1 The mounting arrangements shall be as specified on the Technical Data Sheets (i.e. flange mounted or remotely mounted).

3.5.2 If the actuator is mounted remotely from the valve, a suitable drive shaft shall be provided, incorporating all necessary universal joints, which shall be protected by gaiters. The design life of all drive shaft components shall be greater than or equal to that of the actuator. The actuator mountings/support structure shall accommodate any reaction forces that will occur when the valve is being driven.

3.5.3 In case the actuators have to be mounted in hazardous, inconvenient or difficult to reach positions, it shall be possible to separate the remote / local motor controls (including motor section) from the actuator; or, another (and identical) remote actuator control station shall be mounted separately. Regardless, it shall be possible to operate and configure the actuator remotely.

3.5.4 A wall bracket shall be included as an option and price to mount the remote controls / motor controls near the valve actuator.

3.5.5 If the remote actuator control section is mounted separately from the actuator motor section, the cabling between these two sections shall be included in the price for the actuator system. Power to the local actuator control section shall be taken from the actuator motor section; power from an another source shall not be allowed.

3.5.6 Actuator mounting flanges shall comply with BS EN ISO 5210 for multi-turn actuators and BS EN ISO 5211 for quarter-turn actuators.

3.5.7 The actuator shall be provided with an easily detachable drive coupling. Unless otherwise agreed with the Engineer, the coupling shall be supplied as a blank, for subsequent machining to suit the valve spindle or gearbox input shaft, as appropriate.

3.6 Rating Plate

3.6.1 The actuator shall be provided with an information plate permanently fixed to one of its major components. As a minimum, the information plate shall include the following information:

a) Manufacturer and contact details

b) Model/type

c) Serial number

d) Valve reference number

e) Rated torque (Nm) at start-up and full load

f) Continuous rated output (kW)

g) Speed (rpm or secs/90°)

h) Frequency (Hz)

i) Power Factor;

j) Full load current (A) and starting current (A)

k) Flange reference

l) Actuator voltage and number of phases

m) Class of insulation

n) Lubricant

o) Year of manufacture

3.6.2 Any additional information required on the information plate shall be as specified on the Technical Data Sheets.

3.6.3 The plate and its fixings shall be manufactured from corrosion resistant, non-degradable metal materials and shall be indelibly stamped or engraved.

3.6.4 The information contained on the rating plate shall be clearly accessible and visible after the motor has been painted.

3.6.5 One set of spare engraved rating plates shall be provided with the installation.

3.7 Maintainability

3.7.1 All components that require regular inspection, cleaning or maintenance shall be readily and safely accessible and, where appropriate, easily replaceable.

3.7.2 As far as reasonably practicable, replacement parts shall be modular.

3.7.3 Components shall be uniquely and durably identified for ease of identification and replacement.

3.7.4 All fixtures and fixings shall be made of stainless steel (Grade A4 or equivalent).

3.7.5 Electrical and mechanical disconnection of the motor shall be possible without draining the lubricant from the actuator gearbox.

3.7.6 Each actuator shall be designed to facilitate maintenance. The coupling between the actuator and the valve or sluice gate shall be easily accessible. It shall be possible to do maintenance work on the actuator whilst the valve or sluice gate is in operation under local control.

3.7.7 Actuators required to take the valve opening and closing loads shall be designed to allow access to the actuator for inspection and maintenance without releasing the stem thrust or taking the valve out of service.

3.7.8 In order to minimise the amount of spare parts required, parts such as covers, plug / sockets etc. must be interchangeable throughout the model sizes installed, with reasonable similar frame sizes.

3.7.9 Electrical connection of actuators shall be made via switch disconnector. Data connections shall be designed in order that disconnection of one actuator shall not disconnect the network.

4. ENVIRONMENT AND ENCLOSURES

4.1 Enclosure and Frame

4.1.1 The motor, reversing motor starter, control circuit transformer and all other control equipment shall be housed in a double sealed, common enclosure.

4.1.2 The minimum degree of ingress protection afforded by the enclosure shall be IP 68 (to SANS 60529) for multi turn actuators and IP67 for quarter turn actuators. The actual degree of ingress protection afforded by the enclosure shall be as stated on the Technical Data Sheets.

4.1.3 Adjustments to torque and position limit devices and configuration of indicator contacts shall be achieved by the method specified/stated on the Technical Data Sheets.

4.1.4 The actuators shall be adequately sealed and insulated to guarantee satisfactory operation under a submergence of 10,0 m of water.

4.1.5 All gearing, shaft bearings, torque limiting clutch mechanism limit switch assemblies etc. shall be totally enclosed and adequately lubricated.

4.2 Operating Environment

4.2.1 The operating environment of the actuator (including details of hazardous areas, EMC requirements etc.) shall be as specified on the Technical Data Sheets.

4.2.2 The actuator shall be capable of satisfactory operation within the ambient air temperature range **–**10 °C to + 50 °C and up to a relative humidity of 95 %.

4.2.3 Any special hazards associated with the operating environment shall be as specified on the Technical Data Sheets.

4.2.4 All equipment selected for use in a hazardous area shall have undergone an appropriate conformity assessment procedure (CAP) to demonstrate compliance with the essential health and safety requirements.

4.3 Materials Selection

4.3.1 Materials shall be selected with proper reference to the specified operating environment and the design life of the actuator.

4.4 Corrosion Protection

4.4.1 All metallic components shall be designed and assembled to avoid galvanic corrosion. If necessary, insulating washers and sleeves shall be used to prevent direct contact between dissimilar metals.

4.4.2 Metal plating of ferrous materials, (e.g. zinc or cadmium plating) is not an adequate corrosion protection system for items such as actuator shafts and such items shall be provided with an additional coating of a semi setting, thick protective layer, such as a suitable Tectyl product, or equivalent.

4.4.3 Protection level KN shall be required as for installation in a low level of pollution concentration.

4.4.4 The paint finish shall be appropriate to the operating environment and the design life of the actuator. Details of the paint finish shall be provided with the Tender. The paint colour shall be as specified on the Technical Data Sheets.

5. PERFORMANCE

5.1 Valve type and Duty

5.1.1 The valve type shall be as specified/stated on the Technical Data Sheets.

5.1.2 The valve stem or gearbox input shaft diameter shall be as specified/stated on the Technical Data Sheets.

5.1.3 Unless otherwise specified/stated on the Technical Data Sheets, the valve duty and number of cycles/starts per hour etc. shall be at least 600 starts per hour for modulating valve duty.

5.1.4 The maximum torque required to operate the valve (i.e. close, open or adjust position) shall be as specified/stated on the Technical Data Sheets.

5.1.5 The required valve stroke time (i.e. open to close) shall be as specified/stated on the Technical Data Sheets.

5.1.6 For rising spindle valves where the actuator is directly mounted onto the valve, the output shaft shall be hollow to accept the rising spindles.

5.1.7 For rising stem applications, the design must allow to removal of the actuator from the output drive without disturbing the function of the valve.

5.1.8 Each electric-motor-operated valve shall be fitted with suitable reduction gearing designed to unseat the valve under 75 % of the test pressure of the valve and to operate the valve while water is flowing through the valve at velocities up to 5.0 metres per second. Each operation from the full-open to the full-closed position or vice versa shall be completed within the time stated in the relevant schedules and shall be witnessed by the Engineer's representative at the suppliers works.

5.2 Design Life

5.2.1 Actuators shall be rated S4 to SANS 60034-1, 60 starts per hour at a rate not exceeding 600 starts per hour.

5.3 Rated Torque

5.3.1 The continuous actuator torque rating for regulating duty and for open/shut duty shall be at least 200 % of the start/opening or shut off torque, whichever is higher, specified by the valve manufacturer for this application (after any gearbox mechanical advantage has been taken into account).

5.3.2 The continuous actuator torque rating for actuators for modulating duty shall be at least 400 % of the valve requirement and the actuator shall be specifically designed for continuous modulation.

5.3.3 The safety margin on motor power available for seating and unseating shall be sufficient to ensure torque switch trip at maximum torque with a supply voltage +10/-6 % of the normal rated voltage.

5.4 Noise

5.4.1 Under all operating conditions, the noise levels from the actuator shall not exceed 75 dB(A) at a distance of 1 m from the actuator centre line (based on the actuator being mounted in 'semi-reverberant'/freefield conditions).

5.4.2 The sound power levels shall not exceed the values specified in SANS 10083.

6. DRIVE SYSTEM

6.1 General

6.1.1 Where the actuator operates gate valves or large diameter ball or plug valves, or for ‘on-off’ and ‘inching’ applications, the drive shall incorporate a lost motion ‘hammer blow’ feature (i.e. the motor shall reach maximum speed before engaging the drive). It shall also be possible to apply a ‘hammer blow’ effect manually via the handwheel.

6.1.2 For rising spindle valves, the output drive shaft shall be hollow to accept the rising spindle. Spindles that protrude above the actuator shall be enclosed in a fixed, impact resistant, transparent tube.

6.1.3 For quarter-turn actuators, adjustable mechanical stops shall be provided at 0° and 90°± 5°. These shall be easily adjustable from the outside of the actuator enclosure.

6.1.4 For modulating applications, lost motion between the worm wheel and drive shaft shall be eliminated, to minimise any hysteresis error.

6.1.5 All gearing shall operate with minimum gear backlash. The drive train shall be designed to prevent backlash.

6.1.6 The safety margin of motor power available for seating and unseating the valve shall be sufficient to ensure torque switch trip at maximum valve torque with the supply voltage 10 % below nominal.

6.2 Motor

6.2.1 All motors shall be specifically designed for valve-actuator operation which is characterised by high starting torque, low stall torque and low inertia.

6.2.2 Motors shall be of the non-ventilated totally enclosed type (TENV).

6.2.3 The electric motor shall be a totally sealed, 3-phase squirrel-cage induction type suitable for modulating continuous operating equipment to at least 4 times the sum of the opening and closing time specified in the scope of work. The motor shall have 4 poles or more.

6.2.4 Unless otherwise specified on the Technical Data Sheets, for ‘on-off’ and ‘inching’ applications, the motor shall be rated for 10 minutes at an average load of 33 % of rated torque for multi-turn actuators and 75 % of rated torque for direct quarter-turn actuators.

6.2.5 The motor shall have Class F insulation in accordance with SANS 60085 and shall be rated for a Class B (80 K) temperature rise. Temperature rise shall be measured by the embedded thermo switches in the windings during full load condition, in accordance with SANS 60034-1.

6.2.6 The motor shall be provided with suitable over-temperature and over-torque protection.

6.2.7 Motors must be totally separated from the lubricant-filled gearing of the actuator, allowing replacement of motor without losing any lubricant regardless of mounting position.

6.3 Motor Control

6.3.1 The actuator shall incorporate a suitably rated, reversing motor starter for three phase supplies.

6.3.2 The reversing motor starter shall make use of reversing contactors. The contactors shall be mechanically and electrically interlocked.

6.3.3 The actuator shall be provided with stall protection that shall de-energise the motor if no movement is detected after receipt of a signal to open or close.

6.3.4 All contactors controlling the actuator motor shall be AC 3 duty rated with proper overload protection.

6.3.5 Solid-state motor starters shall be used for modulating duties where the number of starts/hour exceeds 600.

6.3.6 The motor starter shall provide the following features, as a minimum:

a) Single phasing protection

b) Automatic phase rotation correction

c) Overload protection (torque trip protection)

d) Overvoltage protection

e) Motor over-temperature protection; and

f) Instantaneous reversal protection

6.3.7 Any additional features required/provided (e.g. jammed valve protection etc.) shall be as specified/stated on the Technical Data Sheets or suggested by the Manufacturer.

6.4 Integral Reduction Gearbox

6.4.1 The gearbox shall be of 'totally enclosed' design and shall be suitable for operation at any angle.

6.4.2 Unless specified otherwise in the Technical Data Sheets, oil-bath lubrication is preferred for the gearbox lubrication type.

6.4.3 No plastic on nylon gears will be accepted.

6.4.4 If specified on the Technical Data Sheets, the gearbox shall be 'sealed for life'. If sealed for life gearboxes are not required, oil lubricated, gearboxes shall be fitted with oil filling and drain points and an oil level indicator. The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.

6.4.5 Electrical and mechanical disconnection of the motor shall be possible without draining the lubricant from the actuator gearcase.

6.4.6 Gears shall not be subjected to thrust loads from the output shaft. Thrust loads shall be accommodated by a suitably positioned rolling element thrust bearing. The method of thrust bearing lubrication shall be as stated on the Technical Data Sheets.

6.4.7 It shall be possible to inspect and remove/replace gears without releasing the valve spindle thrust or taking the valve out of service.

6.4.8 Permanently sealed bearings are preferred.

6.4.9 In the case of electric actuators that operate through an intermediate gearbox between the valve and actuator a shear pin or other safety device shall be incorporated on one of the gears to prevent damage to the valve spindle and nut if excessive force is applied. Two spare pins shall be attached to each valve. The shear pin shall be designed to withstand the torque to unseat the valve at 75 % of the test pressure.

6.5 Second Stage Gearbox

6.5.1 If necessary, to meet the valve torque and/or stroke time requirements specified, a second stage gearbox shall be fitted to the actuator output shaft. If a second stage gearbox is provided, the gearbox specification shall be provided with the Tender.

6.5.2 The design of the gearbox shall meet the same standards of quality and finish as the actuator.

6.5.3 The gearbox shall be provided with an easily detachable drive coupling. Unless otherwise agreed with the Engineer, the coupling shall be supplied as a blank, for subsequent machining to suit the valve spindle.

6.5.4 If the gearbox is fitted to a quarter-turn actuator, adjustable mechanical stops shall be provided at 0° and 90° ± 5°. These shall be easily adjustable from the outside of the gearbox.

6.6 Manual Operation of Drive

6.6.1 The actuator motor shall have facility for being overridden for emergency shutting of the valve.

6.6.2 A handwheel shall be provided for manual operation of the valve, sized in accordance with BS EN 12570 and shall not move during motor operation.

6.6.3 Unless otherwise specified/stated on the Technical Data Sheets, the handwheel shall be engaged by declutching the motor drive with a lever or similar means and shall automatically and immediately disengage on restoration of the motor drive. The handwheel/lever shall not move on restoration of the motor drive. No damage to the actuator drive mechanism shall occur if manual operation is engaged while the motor is running. If a permanently engaged handwheel is required/provided, it shall be easily removable and/or designed to avoid injury to personnel during motor operation.

6.6.4 Handwheel gearing shall enable one person to manually open/close the valve without undue effort and in a reasonable time period, in accordance with BS EN 12570.

6.6.5 Unless agreed otherwise with the Engineer, clockwise operation of the handwheel shall close the valve.

6.6.6 The opening/closing direction shall be clearly and permanently indicated on the handwheel.

6.6.7 Provision shall be made for the lever engaging the motor to be padlocked to prevent unauthorised hand operation. Handwheels shall incorporate facilities for padlocking in the disengaged position.

6.6.8 The hand wheel shall incorporate.an isolating mechanism to prevent it from turning when the valve is 'being power operated. A direction-of-rotation indicator shall be permanently attached to each hand wheel and a pointer attached to the shaft shall be weather-proof and of robust and rigid design; the embossed markings shall be large enough to be plainly visible from a distance of two metres. A drawing showing details of the indicator offered shall be submitted with the offer. If a detachable crank handle is offered the insertion of this handle shall operate a safety switch to cut off the electric power supply to the motor. The torque and limit switch shall be activated in manual operation of the actuator allowing a signal to be output once the set torque or set limit has been reached.

6.6.9 The actuator shall provide an impact effect to overcome tightly seated valves when the rotation direction of the handwheel is changed.

6.7 Extensions

6.7.1 Actuator extensions shall be designed generally in accordance with the drawings applicable to contract, specification or enquiry.

6.7.2 Where and actuator extension is present, identical flanged connections comprise the interface between valve and actuator extension and actuator extension and valve. Replacement gearboxes may require adapters between the valve flange and the gearbox input.

6.7.3 The actuator extension driving shaft shall be of stainless steel in accordance with BS 970 Gr. 431 S 29 (EN57).

7. WIRING AND TERMINALS

7.1 Wiring

7.1.1 All actuator wiring shall be contained within the main actuator enclosure. External conduit connections between components are not acceptable.

7.1.2 Internal wiring shall be PVC insulated. Cores shall be stranded or flexible.

7.1.3 Cables and cores shall be suitably identified at both ends.

7.1.4 All electrical equipment in the actuator shall be pre-wired and all external connections, including the relevant limit switches and any switches, which may be in excess of those specified, shall be wired to an easily accessible and clearly marked terminal block. The markings on the terminal blocks and the wiring shall correspond to those used on the wiring diagrams. Paper identification markings are not acceptable and non-fading plastic markers shall be provided. The terminal blocks shall be complete with all screws, nuts, washers and spring washers for connecting power and control cables to each terminal supplied.

7.2 Terminal Enclosure

7.2.1 All electrical components shall be wired to terminals, which shall be housed in a common terminal enclosure incorporated within the actuator housing. If specified on the Technical Data Sheets, the enclosure shall be incorporated within the actuator housing, but shall be separated from all internal actuator components by a watertight/dustproof seal, so as to provide ingress protection when the terminal enclosure cover is removed.

7.2.2 The number of cable entries in the terminal enclosure and the cable entry details shall be as specified/stated on the Technical Data Sheets. Cable entries shall be plugged during transit and storage with blanking plugs to prevent the ingress of moisture or foreign matter. Any conduit entries not used shall be plugged with threaded blanks and made water/gas tight using a suitable jointing compound.

7.2.3 Terminals shall be embedded in a terminal block of high tracking resistance compound and be of any approved type complying with SANS 60947-7.

7.2.4 Power and control circuit terminals shall be sized according to the relevant cable conductor cross sectional areas, subject to minimum conductor cross sectional area of 2.5 mm² and 1.5 mm² respectively. Power and control circuit terminals shall be adequately segregated.

7.2.5 A terminal identification schedule/diagram shall be fixed to the underside of the terminal enclosure cover. The diagram shall be printed on a durable material and include:

a) Serial number

b) External voltage values

c) Wiring diagram number; and

d) Terminal layout

7.2.6 The schedule/diagram shall allow space for the electrical installation Contractor to add cable identification details alongside the terminal numbers.

7.2.7 Wiring and schematic diagrams of the control circuit of each valve shall be provided. An installation and maintenance booklet shall be supplied with each valve actuator.

7.2.8 The compartment into which the cables are terminated shall be sealed from the balance of the actuator so that in the event of leakage through the cable gland no damage will occur to the actuator.

7.2.9 Actuators shall be supplied-fitted with tapped steel plug seals in any open orifices or conduit entries. The use of plastic plugs for this purpose is not acceptable. This shall prevent flooding of electrical components prior to wiring up the actuator.

7.3 Earthing and Bonding

7.3.1 Actuator bonding facilities shall be as stated on the Technical Data Sheets.

8. CONTROL AND MONITORING

8.1 General

8.1.1 The actuator shall incorporate all necessary circuits (i.e. wiring, links, terminals etc.) and hand-operated control devices to enable effective local and remote operation.

8.1.2 Under both local and remote control, it shall be possible to reverse travel without the need for a separate stop signal.

8.1.3 If the opening or closing period is specified; e.g. to avoid water hammer; this period shall be achieved by incorporating a suitable gear ratio to allow the motor to operate continuously from fully open to fully closed; i.e. the motor shall not repeatedly stop and start over this period.

8.1.4 If however specified/stated on the Technical Data Sheets, under both local and remote control, it shall be possible to enable automatic pulsed operation, to extend valve opening/closing times and thereby avoid hydraulic shock.

8.1.5 Control of valves shall be by means of non-rising spindles unless otherwise specified.

8.1.6 An anti-condensation heater rated for the specified supply voltage shall be included in the switch compartment.

8.1.7 The actuator protection shall include phase rotation discrimination and single phasing protection.

8.1.8 If it is required that the actuator must close automatically when electrical supply fails, then a spring return or a suitably sized UPS shall be provided.

8.2 Control Circuit Transformer

8.2.1 Control circuit supplies shall be provided by a control circuit transformer that shall have the necessary tappings and be adequately rated to provide power for the following functions:

a) Energising of the motor starter contactor coils, if necessary

b) Power supply for all local (internal) indication/monitoring circuits (24 V DC supply); and

c) Power supply for all remote (external) indication/monitoring circuits, if necessary (24 V DC supply)

8.3 Local Control and Indication

8.3.1 Local Control

a) The actuator shall incorporate the following externally mounted hand-operated control devices:

   i) A ‘Local/Off/Remote’ mode selector switch; and

   ii) A rotary switch or push-buttons to open/close/stop the actuator in ‘Local’ mode.

b) With respect to item a), the selector switch shall be padlockable in any mode and be capable of accepting a 30 mm x 6 mm diameter padlock shackle.

c) It shall be possible to configure local control for maintained or push-to-run (inching) operation.

d) All controls shall be marked as to their function with easy-to-read, durable labels that are permanently inscribed or embossed.

e) The controls shall form an integral part of the actuator and shall be non-intrusive.

f) It shall be possible to rotate local controls through 90° increments to suit the actuator orientation. The local control section shall be capable of being in the upright position independent of the valve and actuator orientation.

g) All built-in protection devices shall still be active during Local operation of the actuator.

8.3.2 Local Indication

a) Local indication of valve position by means of a back lit liquid crystal display or mechanical indicator giving position indication.

b) Electronic displays shall be capable of maintaining and updating valve position data on loss of external power to the actuator.

c) Mechanical indication shall be continuous in relation to valve movement.

d) LED indicators shall be provided to indicate whether the valve is fully open, fully closed or in an intermediate position. The colours of the LED indicators and their meanings shall be as specified/stated on the Technical Data Sheets.

e) If specified/stated on the Technical Data Sheets, valve, actuator and control system status information (e.g. reporting of specific types of fault) shall be available local to the actuator.

f) It shall be possible to rotate local indicators through 90° increments to suit the actuator orientation. The local display shall be capable of being in the upright position independent of the valve and actuator orientation.

8.4 Remote Control and Monitoring

8.4.1 Remote Control

a) The control circuit supply details shall be as specified/stated on the Technical Data Sheets (i.e. internal 24 V DC supply and/or external supply (240 V AC)).

b) The actuator shall incorporate all necessary circuits (wiring and terminals etc.) to provide the following remote control functions, as a minimum:

i) Open/Stop/Close (maintained), 4 wire control

ii) Open/Close (maintained), 3 wire control, mid-travel reversal; and

iii) Open/Close (non maintained i.e. ‘push to run’ (inching)), 3 wire control

c) Any additional functions required/provided (e.g. emergency shutdown to open or close the valve or maintain position, etc.) shall be as specified in the Particular Specification.

d) If specified on the Technical Data Sheets, the actuator shall be provided with a two-wire 4-20 mA positioner to enable it to respond to an analogue input signal to vary valve position. Unless otherwise specified on the Technical Data Sheets, 4 and 20 mA shall correspond to the fully closed and fully open positions respectively. Unless otherwise specified on the Technical Data Sheets, the repeatability of the controller shall be within 1.0 %.

e) Opto-isolated devices shall be provided to interface the actuator internal circuits with the remote controls.

8.4.2 Remote Monitoring

a) Unless specified otherwise in the MCC Table, the output signals required/provided shall be for the indication of fully open, fully closed and intermediate position.

b) Output signals shall be provided by a monitor relay with a volt-free changeover contact and an appropriate number of latching, volt-free, single-pole contacts, configurable to be either ‘normally open’ or ‘normally closed’. Position signals shall remain available and updated during loss of mains power supply. Contacts shall be rated at 5 A, 30 V DC/240 V AC.

c) If specified/stated on the I/O list, the actuator shall incorporate a device to provide a 4-20 mA analogue signal proportional to valve position.

d) If specified/stated on the I/O list, the actuator shall incorporate a device to provide a 4-20 mA analogue signal proportional to actuator output torque.

e) If specified/stated on the Technical Data Sheets the actuator shall be suitable for remote control and monitoring via a fieldbus system. The communications protocol shall be as specified/stated on the Technical Data Sheets.

f) An indication light shall be provided on the panel to indicate whether the actuator is switched in 'Local/Off/Auto' setting.

g) Indication lights shall be provided on the panel to indicate whether the valve is fully open, fully closed or in an intermediate position. The colours of the LED indicators and their meanings shall be as specified/stated on the Technical Data Sheets.

h) Five additional potential free contacts programmable by the user to indicate functions such as high torque, thermostat tripped and remote selected.

i) Actuators supplied with internal batteries for memory back-up purposes shall have battery facilities with a potential free contact.

j) For modulating valves, information pertaining to intermediate valve position and torque on output shaft shall be fed back to the control system and shall be indicated on the SCADA.

8.5 Disconnecting Device

8.5.1 Each actuator shall have one easily accessible (within arm's reach) IP68 rated electrically disconnecting device to disconnect the entire actuator installation from the electrical power supply.

8.5.2 The disconnecting device is intended for repair, maintenance and/or inspection and shall have at least the safety isolating requirements of a switch-disconnector.

8.5.3 The switch-disconnector shall be mounted within arm's reach from the terminals of the appliance and shall be padlockable.

8.5.4 The switch-disconnector shall disconnect all phase conductors but need not disconnect the earth conductor.

8.6 Diagnostics

8.6.1 The actuator shall incorporate a diagnostic module that will store and enable download of historical actuator operation and torque data to permit analysis of actuator and valve in-service performance. Data shall be available locally or remotely via telecom data transfer. Diagnostic and configuration software shall be made for user PC and PDA (personal digital assistant) systems.

8.7 Torque and Position Limit Devices

8.7.1 The actuator shall incorporate torque and position limit devices, selectable in any combination, for the setting of open and close limits (e.g. it shall be possible to stop valve travel in the 'fully closed' position by torque limitation to ensure proper seating of the valve, with the 'fully closed' position limit devices adjusted to be inoperative).

8.7.2 The torque limit device shall trip the motor starter if the actuator is overloaded due to the valve being obstructed or jammed. However, it shall be possible to inhibit the torque limit protection system for parts of the valve travel adjacent to the closed and open limit positions to aid valve seating/unseating. In addition, it shall be possible to inhibit torque protection during starting/reversing in mid-travel against high inertia loads.

8.7.3 Torque and position limit devices shall be easily and accurately adjustable within the ranges 40-100 % rated torque and over the full range of valve travel. It shall be possible to adjust position limit devices in a safe manner without coming into contact with live terminals.

8.7.4 All position limit devices shall function correctly when the actuator is operated manually (e.g. during isolation).

8.7.5 If specified on the Technical Data Sheets, a number of additional sets of position limit devices shall be provided to enable an additional switching point to be set for each direction of rotation (e.g. to signal a certain valve position or start/switch off any related item of plant).

8.7.6 The electrical circuit diagram of the actuator shall not vary with valve type; remaining identical regardless of whether the valve is to open or close on torque or position limit.

8.7.7 For high speed applications, torque limiting brakes shall be supplied to prevent excessive valve seat loading.

8.8 Control Signal Facilities

8.8.1 The various actuators shall either be equipped with a mechanism by which either an analogue 4 - 20 mA signal is generated in proportion to the status of the valve or sluice gate setting to facilitate proportional control, or the actuators shall be actuated by a digital signal which causes them to open fully or close fully.

8.8.2 The two types of electric actuator shall have the following control/signal facilities (type A = open/close, type B = modulating):

a) Open/Closed Valve

   i) Open coil - 240 V AC - Facilities to open the valve by means of a potential free contact.

   ii) Close coil - 240 V AC - Facilities to close the valve by means of a potential free contact.

   iii) Potential free contact to signal that the valve is open.

   iv) Potential free contact to signal that the valve is closed.

   v) Potential free change over contact to signal local "Local/Off/Remote" selection.

b) Modulating Valve

   i) Position signal: 4 - 20 mA.

   ii) Position feedback: 4 - 20 mA.

   iii) Potential free changeover contact to signal local "Local/Off/Remote" selection.

9. DRAWINGS AND DOCUMENTATION

9.1 General

9.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with the Employer's name and project / scheme / contract reference title and numbers, the Employer's representative's name and reference numbers, and the Manufacturer's works / contract / order references.

9.2 Drawings

9.2.1 Detailed "as-built" drawings shall be provided by the Contractor showing positions of the actuators and cable routes.

9.2.2 Sufficient details will be given on the drawings to enable replacement parts to be made locally.

9.3 Drawings and Documentation for Approval by the Engineer

9.3.1 The following documentation and drawings shall be submitted to the Engineer:

a) Prior to procurement

Detailed actuator list including tag number, supplier, location, failsafe positions signal and communication.

b) Prior to installation

Hook-up and loop drawings

9.4 Operating and Maintenance Manual

9.4.1 Three fully indexed Operation and Maintenance Manuals and three Certification copies shall be provided for all motors supplied. A draft copy shall be submitted to the Engineer for approval. The operating and maintenance manuals shall include at least the following (manual's format shall be of A4):

a) A schedule of all components equipment in the installations with the following information shall be provided:

   i) Manufacturers name and contact details

   ii) Actuator tag number

   iii) Function (e.g. 'Sludge Valve)

b) Full description and details of design capacity and design criteria for each item of equipment and each product.

c) Procedures for fault finding.

d) Maintenance instructions for all actuators and components and including repair, overhaul, change-out and installation procedures.

e) All special tools required for the maintenance and overhaul of all the equipment shall be listed.

f) Details of the maintenance tasks and schedules required to achieve the specified actuator asset life.

g) A schedule giving the complete list of spares which should be ordered.

9.5 Information to be Supplied with Tender

9.5.1 A set of complete Technical Data Sheets from the actuator Manufacturer for every type of actuator provided.

9.5.2 A general arrangement (GA) drawing of the actuator indicating the designation, overall dimensions/footprint and typical layout of key components/systems.

9.5.3 A lubrication schedule detailing all components/systems requiring lubrication, the method and frequency of lubrication and the type and manufacturer of the lubricants.

9.5.4 A schedule of spares required for 2 years of normal operation (plus associated costs, lead times, supplier or local agent contact details).

9.5.5 Motor speed/toque curves.

10. TESTING AND COMMISSIONING

10.1 General

10.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.

10.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.

10.1.3 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.

10.1.4 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Contract Conditions, the period of notice for witness testing shall be 5 working days.

10.1.5 If there is a requirement for additional inspection and test activities to be performed as part of process commissioning, this shall be specified in the Particular Specification.

10.1.6 Unless otherwise agreed by the Engineer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

10.2 Inspection and Test Sequence

10.2.1 Factory Acceptance Testing (FAT)

a) Each actuator shall be performance tested at the Supplier's Works. Reports of actuator type testing shall be made available to the Engineer, on request.

b) The test equipment shall simulate a typical valve load and the following parameters shall be recorded:

i) No Load Current

ii) Motor current at maximum torque setting

iii) Actuator torque at maximum torque setting

iv) Test voltage and frequency

v) Flash test voltage

vi) Actuator output speed or operating time; and

vii) Actuator stall torque

c) A test certificate shall be provided free of charge. In addition to the parameters listed above, the test certificate shall record design details such as gear ratios for manual and automatic operation (including any details of second stage gearing, if provided), drive closing direction and wiring diagram number.

10.2.2 Inspections Before Testing

Before testing, inspections shall be performed to verify:

a) all equipment and material is of the correct type and complies with applicable SANS and IEC standards

b) all parts of the installation are correctly selected and erected

c) no part of the installation is visibly damaged or otherwise defective

d) the installation is suitable for the environmental conditions; and

e) the installation complies with this Specification

10.2.3 Tests before supply is connected

On satisfactory completion of the inspections specified and before the supply is connected, the following tests shall be undertaken in the sequence listed:

a) Continuity of conductors:

   i) Earthing conductor

   ii) Main bonding conductors

b) Insulation resistance:

   i) Site applied insulation, where applicable

c) Protection by separation of circuits, where applicable

d) Protection by barriers or enclosures provided during erection, where applicable

e) Insulation of non-conducting floors and walls, where applicable

f) Polarity

g) Earth electrode resistance, where applicable

10.2.4 Tests after supply is connected

On satisfactory completion of the tests specified and after connection of the supply, the following additional tests shall be performed in the sequence listed.

a) Re-check of polarity

b) Phase rotation, unless otherwise ascertained

10.2.5 A final inspection record shall be supplied with each actuator. This shall include the following information:

a) General actuator data

b) Nominal current

c) No load current

d) Starting current

e) Power factor at rated torque

f) Output speed

g) Torque switch setting

h) Limit switch setting (turns/stroke)

i) High voltage test

j) Functional test (including all options)

k) Visual test

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Engineering Specification

Fire Detection and Alarm System (FDAS) Installations

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Contents

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1. SCOPE

1.1 Application

1.1.1 The intent of this specification is to ensure the construction of a safe and reliable fire detection and alarm system.

1.1.2 This document specifies the standard requirements for:

a) The supply of fire detection and alarm system equipment.

b) The installation of a fire detection and alarm system.

c) The testing and commissioning of a fire detection and alarm system.

1.2 General

The following definitions are used in this specification:

1.2.1 The term “Employer” shall mean the person named as Employer in the Appendix to the tender and the legal successors in title to this person.

1.2.2 The term “Contractor” shall mean the person(s) named as contractor in the Tender acceptance letter by the Employer.

1.2.3 The term “Engineer” shall mean the person appointed by the Employer to act as the Engineer for the purposes of the contract.

Refer to the Project Specification for the applicable standard to use for the specific project either South African National Standards (SANS) or British Standards (BS).

1.3 System Architecture

1.3.1 The design of the installation shall address the following characteristics:

a) Type of system.

b) Type of protection and coverage.

c) The zoning of the premises.

1.3.2 The system shall consist of a central control unit connected to field devices such as detectors, manual call points and annunciation devices via a cable loop.

1.3.3 The control unit shall continuously monitor the status of all sensing devices and initiate an action according to their status.

1.3.4 The operation of the system shall be configurable according to the Employer requirements.

1.4 System Characteristics

1.4.1 The system shall be an addressable or conventional system capable of communicating with multiple external systems such as fire extinguishing system, smoke detection and extraction system, HVAC system, lifts, access control system, all via logical programmable input/output units.

1.4.2 Field devices shall be connected in a closed loop configuration or individual wires per each device depending on the type of system installed, and connecting back to the main fire panel.

1.4.3 The fire detection control unit shall monitor the status of field devices on a continuous basis.

1.4.4 Based on the information gathered from the field devices, the control unit will report any fault and alarm conditions and initiate the appropriate actions.

1.4.5 The system shall be field configurable from the control panel via a keypad or via a computer workstation. Final configuration should be maintained under power failure conditions.

1.4.6 The system shall have a minimum of four access levels e.g. operator, supervisor, maintenance technician and administrator. The system shall be password protected

1.4.7 The system and all field devices shall be protected against over voltage and transient currents.

1.4.8 The control unit shall be modular in design and have facilities to operate as a stand-alone unit or as part of a network, consisting of multiple control units.

1.4.9 All equipment that requires operation, attendance, cleaning or maintenance in service shall be positioned and installed to allow adequate and safe means of access for such activities. Similarly, the positioning of equipment shall not impede access to any other equipment or services which require operation and maintenance activities.

1.4.10 Where refurbishments in the form of additions or alterations to an existing installation are to be performed, the compatibility of existing and new equipment shall be verified and confirmed in writing to the Engineer before commencement of any works.

1.4.11 Shop drawings and connection diagrams of the Fire Detection System configurations shall be provided by the Contractor.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detailed specification of the project or site specific requirements will be found in the Project Specification, which shall be read in conjunction with this specification.

2.1.2 The supply, construction, testing and commissioning of the installation shall comply with all relevant Statutory Regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards or British Standards.

2.1.3 The decreasing order of precedence of these requirements shall be as follows:

a) Statutory requirements.

b) National Standards.

c) Employer's requirements.

d) Particular Specification.

e) Construction Drawings.

f) This Specification.

2.1.4 Any items not specifically detailed in this specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included or raised with the engineer in writing by the Contractor.

2.1.5 The Contractor shall operate an auditable quality assurance procedure covering the supply, construction, inspection and testing of the installation.

2.2 Regulations, Specifications and Standards

2.2.1 The supply, construction, inspection and testing of the Installation shall comply with all relevant Statutory Regulations and Directives including:

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

b) Construction Regulations 2003 issued in terms of Section 43 of the Act.

c) Local Fire Regulations.

2.2.2 The latest editions (current at the time of Tender) of the following South African National Standards or British Standards shall be included:

Table 1 Standards

SANS Number	BS Number	Description
SANS 10139	BS 5588	Fire detection and alarm systems for buildings – System design, installation and servicing Building Regulations
SANS 10142-1	BS 7671	Wiring of Premises Part 1: Low Voltage Installations
SANS 10400		Building Regulations
SANS 50054-1	BS 5839	Fire detection and alarm systems – Part 1: Introduction
SANS 50054-2	BS 5839	Fire detection and alarm systems – Part 2: Control and indicating equipment
SANS 50054-3	BS 5839	Fire detection and alarm systems – Part 3: Fire alarm devices – Sounders
SANS 50054-4	BS 5839	Fire detection and alarm systems – Part 4: Power supply equipment
SANS 50054-5	BS 5839	Fire detection and alarm systems – Part 5: Heat detectors – Point detectors
SANS 50054-7	BS 5839	Fire detection and alarm systems – Part 7: Smoke detectors – Point detectors using scattered light, transmitted light or ionization
SANS 50054-11	BS 5839	Fire detection and alarm systems – Part 11: Manual call points
SANS 50054-20	BS 5839	Fire detection and alarm systems – Part 20: Aspirating Smoke Detectors

2.2.3 The installation shall also comply with:

a) This specification including any documentation issued by, or on behalf of, the Employer in respect of the installation.

b) EN54 - Fire Detection and Fire Alarm Systems.

c) British Standards BS 5839 Pt1 - Fire Detection and Fire Alarm Systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises.

d) National Fire Protection Association, NFPA Part 13 – Installation of Sprinkler Systems.

3. COMPONENTS AND EQUIPMENT

3.1 General

3.1.1 All equipment and components shall be suitable for their operating environment, particularly with respect to the following:

a) The degree of ingress protection against dust and moisture (IP rating).

b) The corrosion resistance of the materials of construction.

c) Mechanical properties.

3.2 Fire Detection Control Panel

3.2.1 General

a) The control panel shall have a front panel comprising of a LCD screen, control keyboard and indicating LED’s.

b) The control panel shall be a 24Vdc analogue addressable or conventional unit and be able to communicate with various field devices.

c) The control panel will not only read the address of each individual unit, but also receive their true analogue value.

d) The control panel will be equipped with a minimum of 2 loops and a minimum 64 zone capacity and be upgradeable to the maximum prescribed loops as per the project specification without the need for additional housing.

e) Each loop shall consist of a 2 wire cable. These 2 wires will power the field devices and carry data to and from these field devices. Each loop will allow for a minimum of 127 addresses. The specific number of addresses required shall be specified in the project specification.

f) The fire panel will not have any pre-set configuration of field device addresses. Address configuration will be determined during commissioning.

g) The fire panel shall be able to determine the type of device located at each address to protect against incorrect programming.

3.2.2 Annunciation

a) LED indicators shall show faults and fire alarms by zones.

b) The following conditions will be clearly displayed on the LCD text display along with an audible alarm and where applicable the LED indicators:

i) Fire alarms by zone.

ii) Pre-alarms.

iii) System faults.

iv) Maintenance indication level.

v) Device or zone that has been disabled.

vi) Total number alarm events.

3.2.3 Fire alarms shall take priority on the LCD display.

3.2.4 On manual request it shall be possible to view field devices, along with their analogue addresses and current status.

3.2.5 Different types of alarm conditions must be clearly distinguishable.

3.2.6 The control panel shall provide communication outputs for network capabilities, audible alarms, control functions, remote mimics, a printer and a computer workstation.

3.2.7 The control panel shall be able to receive and transmit various inputs and outputs to and from e.g. sprinkler systems, air conditioning installations, lifts etc.

3.3 Power Supply

3.3.1 Power Supply

a) A control panel shall be fed from a 230V supply or an emergency (standby) mains power supply.

b) Power supply to be fed from the nearest distribution board via a dedicated switched socket outlet or isolator.

c) Conductor size shall be a minimum of 2.5 mm^2 PVC insulated.

d) The standby batteries for the system shall be capable of providing a minimum standby time of 24 hours with the system in alarm state.

3.4 Detectors

3.4.1 General

a) All detectors shall be of the analogue addressable or conventional type as indicated in project specification. Each detector shall be assigned with a unique address. It shall be possible to set individual addresses in the field.

b) Detectors shall be suitable for connecting to a two-wire 24Vdc circuit and operate within the supply voltage range of 17 - 28Vdc. The detectors shall also be polarity insensitive.

c) A red indicator LED shall be provided on each of the detectors, the LED will illuminate when a pre-set alarm level has been reached.

d) Provision shall be made for a remote indicator output on each detector.

e) All detectors are to be supplied complete, fully tested and calibrated.

f) Detectors shall be capable of being remotely tested from the fire panel via transmission of a test code. A healthy response will indicate that that detector has exceeded its alarm threshold and is now in alarm mode.

g) The detector shall be capable of operating within the following environmental range:

i) Temperature range: -20°C to 60°C.

ii) Humidity range: 0% to 95%.

iii) Ingress Protection rating: IP 43.

3.4.2 Detector Base

a) Separate mounting bases are required to enable easy removal of detectors for maintenance and replacement purposes.

b) There shall be a facility on each base for inserting an indicator tag. The indicator tag shall be clearly visible and indicate the base address.

c) Bases shall be fitted with stainless steel terminal spring, terminal screws and saddles.

d) Insertion and removal of field devices shall be through a twist operation of the device.

3.4.3 Photoelectric or Optical Smoke Detector.

a) The optical smoke detectors shall be suitable for detecting visible smoke such as produced by smouldering fires including burning PVC.

b) It shall be of the light scattering type using a pulsed internal LED light source and a photocell sensor.

c) The construction of the detector shall be of self-extinguishing ABS plastic. Circuitry shall be protected against moisture. Smoke entry points must be protected against dust and insects. The detector covers shall remain on during construction to prevent dust contamination and shall only be removed prior to testing and commissioning.

d) Detectors maximum mounting ceiling height shall be 12.5 m.

e) The contamination level of a detector's photo-optical chamber will cause the detector output signal to gradually change. The control panel shall be capable of monitoring this change in signal and indicate when a level is reached that requires servicing of the detector.

3.4.4 Thermal Heat Detector:

a) The Detector shall monitor ambient temperature by means of an exposed transistor.

b) The construction of the detector shall be of self-extinguishing ABS plastic. Circuitry shall be protected against moisture.

c) Detectors maximum mounting ceiling height shall be 7.5 m.

d) All heat detectors shall have both rates of temperature rise and maximum temperature level detection capabilities.

3.4.5 Infra-red Flame Detector

a) The flame detector must be of the dual infra-red type and include solar blinding.

b) Both alarm and fault relays must be incorporated.

c) The detector spectral response distance shall be between 1 and 2.8µm.

d) The detector shall be capable of detecting hydrogen flames.

3.4.6 UV Flame Detector

a) Both alarm and fault relays must be incorporated.

b) The ultra violet flame detector shall have a spectral response distance of between 185 and 260 nm.

c) The detector shall have a field of view of no less than 100°.

3.4.7 Multi Detector

a) A multi detector shall have both thermal and optical sensing capabilities; these are to provide warning on both types of alarm conditions.

b) Multi detectors shall fully comply with the requirement as specified for optical and thermal detectors.

c) The optical and thermal element of a multi detector shall be able to report to the fire panel individually

3.4.8 Linear Beam Detectors

a) Linear beam detectors shall comply with EN45-12 and shall measure smoke obscuration of an infrared beam between two points from 8m to 100m apart.

b) They shall be reflective type requiring active electronics at only one end of the beam with a passive reflector at the other end.

c) It shall be possible to power the beam detector directly from the address loop.

3.4.9 Aspirated High Sensitive Smoke Detectors

a) Aspirated High Sensitive Smoke Detectors (HSSD) shall comply with SANS 50054-20/EN54-20.

b) The HSSD shall be of an aspirated type and shall be able to draw a sample of the atmosphere in a protected space via fans or pipework into the fire detector usually installed remotely from the protected space

c) It draws air from aspirated pipe lengths to a laser based smoke detector capable of sensing smoke down to obscuration levels.

d) The fire alarm threshold and the two pre-alarm threshold shall be configurable

e) All HSSD detectors shall have the facility to adapt their sensitivity automatically to ambient conditions.

f) The specification of the pipes shall be as indicated in the project specification.

3.5 Manual Call Points

3.5.1 Break Glass Unit

a) The construction of the unit shall be of red self-extinguishing polycarbonate plastic.

b) The unit shall be operated by breaking the glass insert, and the alarm condition shall be maintained until the glass insert has been replaced.

c) A red indicator LED shall be provided on each of the units; the LED will illuminate when the glass insert is broken and indicate the alarm status.

d) The glass insert shall be replaceable using a re-settable tool.

e) It shall be possible to test each unit by inserting a test tool at the bottom of the unit. This test tool shall simulate an alarm condition, without breaking the glass

f) The unit shall be fitted with a cover and seal to eliminate tampering.

g) The unit shall be mounted on a 100mm x 100mm back plate and not directly against walls and concrete surfaces.

3.6 Isolators

3.6.1 Zone or Loop Isolator

a) The isolator shall be able to connect into the loop circuit and monitor the loop for short circuits.

b) In the event of a short circuit, the isolator on each side of the short circuit is to disconnect and isolate the short circuit. This will enable the remainder of the system to function normally.

c) A red indicator LED shall be provided on each of the units, the LED will illuminate when the isolator is in the open position.

3.7 Input/Output Units

3.7.1 General

a) The I/O units shall be connected to and powered from the same two wire loop as the detectors and manual call points for the designated area.

b) The unit shall allow for “Normally Open” and “Normally Closed Contacts”

c) All inputs shall be monitored by an end of line resistor.

d) All outputs shall be changeover relays. The relays shall be of the magnetic latch type to limit current consumption on the two wire loop.

e) A red indicator LED shall be provided on each unit, the LED will illuminate when any fault condition occurs at the I/O unit.

f) Each I/O unit shall only be assigned one unique address, but nevertheless allow for individual operation of that module's inputs or outputs.

3.7.2 The minimum available range of units shall be as follows:

a) 1 Input module

b) 2 Input / 1 Output module

c) 2 Input / 2 Output module

d) 4 Input module

e) 4 Input / 4 Output module

3.8 Annunciation Devices

3.8.1 Siren/Strobe Circuit Controller

a) The controller shall be connected to the two wire loop and locally drive and monitor sirens external to the closed loop.

b) The controller shall have its own power supply and operate through polarity reversal.

c) The controller shall monitor the following:

i) Siren loop for short and open circuit.

ii) Its own 24Vdc power supply with standby time of 24 hours in alarm mode.

iii) The mains voltage before rectifying.

d) A Controller should be able to operate continuously for a fire alarm within its zone and any adjacent zones. This operation should be programmable.

3.8.2 Loop Siren

a) Sirens shall comply with the following minimum specifications:

i) Operating voltage : 24 Vdc

ii) Current consumption : 18 mA

iii) Sound output : 101dB at 1 m

iv) Indoor ingress protection : IP 41

v) Outdoor ingress protection : IP 65

vi) Operation temperature : -10°C to +60°C

b) The Siren shall be constructed from a red self-extinguishing ABS plastic and be supplied along with a siren base.

3.8.3 Strobe Light

a) Strobe lights shall comply with the following minimum specifications:

i) Operating voltage : 24 Vdc

ii) Current Consumption : 68 mA

iii) Flash energy : 0.7 Joule

iv) Flash frequency : 1 Hz

v) Indoor ingress protection : IP 41

vi) Outdoor ingress protection : IP 65

vii) Operation temperature : -10°C to +60°C

b) The strobe light body shall be constructed from a red self-extinguishing ABS plastic. The lens will be constructed from a polycarbonate plastic.

3.8.4 Strobe/Siren combination

a) A strobe/siren combination unit shall fully comply with the requirement as specified for sirens and strobe lights.

b) The siren and strobe light elements of the combination unit shall be able to receive communications from the fire panel individually.

3.9 Remote Link

3.9.1 Remote link to the fire brigade

a) Transmitting equipment shall be required to submit a general fire alarm to the local fire brigade.

b) The transmitting equipment shall be fully compatible with the receiving equipment already installed at the fire brigade. The type of transmitting equipment is therefore dependant on the type of equipment the fire brigade has installed. It is the Contractors responsibility to ensure compliance.

c) The output to the fire brigade shall be a monitored output.

3.10 Software Package

3.10.1 Monitoring and configuration software package

a) A software package shall be provided along with the fire detection control panel, which shall provide for the following minimum functions:

i) System configuration

ii) Event logging

iii) Alarm acknowledgement

iv) Password protection

b) The software package installed shall come complete with license and installation disks.

c) Renewal of licence shall be included. No yearly subscription shall be allowed

3.11 Cabling

3.11.1 Fire Detection Loop cable

a) The 2 wire cable shall be of the PH 30 as minimum requirement fire retardant type with red outer sleeve. This cable shall have 30 min survival time according to SANS 50200 or BS84-34 part 2.

b) Enhanced fire resisting cables shall have PH 120 classification and should have 120 min survival time according to SANS 50200 or BS84-34 part 2.

4. INSTALLATION OF COMPONENTS AND EQUIPMENT

4.1 General

4.1.1 All equipment shall be securely mounted using proprietary fixtures and fittings.

4.1.2 The method of equipment installation shall not adversely affect the function or structural integrity of the structure to which the equipment is attached.

4.1.3 The method of equipment installation shall not compromise the IP rating of the equipment.

4.1.4 Framework and brackets

a) Unless otherwise approved in the Project Specification, site-fabricated framework and brackets shall not be used.

b) Framework and brackets shall be positioned so as not compromise the removal and replacement of equipment.

c) Where it is necessary to modify on site any pre-fabricated galvanised mild steel framework, the cut edges shall be dressed and treated immediately with an approved cold galvanising paint to prevent corrosion.

d) Fasteners securing equipment to framework and brackets shall be independent of those securing framework and brackets to walls and floors.

4.1.5 Positioning of Equipment

a) Final positions of equipment shall be agreed on site, prior to installation.

b) Equipment shall be positioned with due regard to the aesthetics of the installation.

4.1.6 Unless otherwise specified, mounting heights shall be as follows:

Table 2 Mounting Heights

	top frame 2000 mm above finished floor level
I/O Units	underside 2200 mm above finished floor level
Manual Call Points	underside 1200 mm above finished floor level

4.1.7 The detectors and detector bases shall always be installed in such a way that the indicator tag and LED alarm indicator is easily seen from the point of access to that area.

4.1.8 All surface mounted equipment shall be solidly fixed to walls or soffits by means of their back plates.

4.2 Cables

4.2.1 The cable installation shall comply with the requirements of SANS 10142-1 or BS 7671

4.2.2 Cables shall, as far as possible, run parallel with the lines of building construction.

4.2.3 Cables and their support systems shall not be fixed to protective barriers, guards or direct to guard-rails.

4.2.4 Cables shall be installed strictly according to the manufacturers' requirements pertaining to:

a) Maximum tensile or compressive stresses (e.g. due to pinching or squashing).

b) Minimum bending radius.

c) Temperature of installation.

d) Operating environment.

4.2.5 Installation of Cables in Conduit

a) The cable installation in the conduit shall conform to part 6.5.6 of SANS 10142-1 or BS 7671.

b) Conduit shall be debugged and swabbed prior to cables being pulled in.

c) The entire conduit system shall be complete prior to installing cables.

d) Loops supplied from different fire control panels shall not be installed in the same conduit.

4.2.6 Looping and joints

a) A loop-in wiring system where conductors are looped from outlet to outlet shall be employed.

b) No joints shall be allowed in the cables without the prior approval of the Engineer.

c) The use of PVC insulation tape is not acceptable.

4.2.7 Pulling-through of conductors

a) The contractor shall take utmost care whilst pulling conductors through conduit to ensure that the conductors are not kinked, twisted or strained in any manner.

b) Care shall furthermore be taken to ensure that conductors do not come into contact with materials or surfaces that may damage or otherwise adversely affect the insulation and durability of the conductor.

4.2.8 Cabling inside vertical wire ways

a) Conductors installed in vertical wire ways shall be secured at intervals not exceeding 2000mm to support the weight of the conductors.

b) Proprietary or approved clamps shall be supplied and installed in suitable draw-boxes for this purpose.

4.2.9 Method of Cable Support

a) Fixing of cables to containment shall be via appropriate cable metallic straps, clamps and clips.

b) No cable ties shall be used in the installation.

c) Cables should be strapped to cable containment or supports every 500mm.

d) The methods of cable support should be non-combustible and their installation should not in any way compromise the integrity of the circuit. The cable support material should be of a material that can withstand a similar temperature and duration to that of the fire rated cable whiles maintaining adequate support.

5. DRAWINGS AND DOCUMENTATION

5.1 Generals

5.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with the Employer's name and project / scheme / contract reference title and numbers, the Employer's representative's name and reference numbers, and the Manufacturer's works / contract / order references.

5.1.2 All documentation shall be detailed and be written to enable any supplier or maintenance organization to maintain the system.

5.2 Drawings

5.2.1 "As-built" drawings shall be computer generated through a recognised CAD software package. Drawings submitted for acceptance shall be provided on A3 paper size.

5.2.2 Final "As-built" drawings shall be submitted in A0 paper format and in PDF format, on CD. Paper copies are to be neatly folded and placed in a perspex cover sleeve.

5.2.3 The detailed "As-built" drawings shall be provided by the Contractor showing positions of the following.

a) Equipment (e.g. Panels, Detectors, Sirens etc.).

b) Wire ways (e.g. Conduit, Cables ladder, Cable Trays etc.).

c) Cable Routes.

5.3 Mimic Panels

5.3.1 Passive Mimic Panels

a) The panel shall consist of a laminated paper display placed inside an aluminium frame behind a clear perspex sheet. The size will be project dependant.

b) The following shall be clearly indicated on the display:

i) Building floor plan.

ii) All field devices.

iii) Zones clearly outlined in colour.

iv) Building name.

v) "You are here" arrow.

c) The laminated paper display placed inside an aluminium frame shall be computer generated through a recognised CAD software package.

5.4 Operating and Maintenance Manual

5.4.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied, all in A4 format. One electronic set shall also be provided in CD or DVD format. The operating and maintenance manuals shall include at least the following:

a) A schedule of all components in the installations with the following information provided:
   i) Manufacturers name and contact details
   ii) Loop and Zone
   iii) Function
b) Full description and details of design capacity and design criteria for each item of equipment and each product.
c) Detailed description of the function of all operator controls.
d) Procedures for fault finding.
e) Maintenance instructions for all components, including repair, overhaul, change-out and installation procedures.
f) Inspection schedules.
g) Testing procedures.
h) Commissioning procedures.
i) Operator training manuals.
j) “As-built” drawings.

6. TESTING AND COMMISSIONING

6.1 General

6.1.1 The installation shall be inspected and tested in accordance with all the SANS 10139.

6.1.2 Inspection and testing shall only be performed by personnel with approved and current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.

6.1.3 The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall be covered by a current test and calibration certificate.

6.1.4 Unless otherwise specified in the Project Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10139 or BS 5839 or BS 5588.

6.1.5 The SAQCC certificates to be issued once final commissioning has been completed. Contractor to submit report to Engineer.

6.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed by the Engineer. Unless otherwise specified in the Project Specification, the period of notice for witness testing shall be 5 working days.

6.1.7 If there is a requirement for additional inspection and test activities to be performed as part of process commissioning, this shall be specified in the Project Specification.

6.1.8 Unless otherwise agreed by the Employer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

6.2 Testing and Commissioning

6.2.1 Before testing and commissioning, inspections shall be performed to verify:

a) All equipment and material is of the correct type and complies with applicable SANS or BS standards.

b) All parts of the installation are correctly installed.

c) No part of the installation is visibly damaged or otherwise defective.

d) The installation is suitable for the environmental conditions.

e) The installation complies with this Specification.

6.2.2 On satisfactory completion of the inspections the following tests shall be performed in the sequence listed:

a) A power failure shall be simulated to test the standby power supply.

b) Cables and wiring should be insulation tested at 500V after they are installed. The insulation resistance to earth and between conductors should comply with the requirements of SANS 10142-1 or BS 7671. Because 500V can damage electrical and electronic equipment, the insulation test should be carried out before equipment is connected to the cables or wire. The completed installation should be tested at a lower voltage, as recommended by the manufacturer.

c) Earth continuity should be tested in accordance to SANS 10142-1 or BS 7671.

d) Each detector and manual call point should be dynamically tested to ensure that they work satisfactorily, and that the correct indications and responses are given by the fire control panel.

e) The siren should be tested to ensure that the correct sound levels are achieved throughout the building.

f) All signals from the fire control panel to ancillary systems should be checked to ensure that the correct actions or responses are achieved.

g) The remote link to the fire brigade should be tested if installed.

h) After individually testing the components and equipment, fire simulation tests shall be done to commission the system and to indicate that the system is working.

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General Electronic Installations

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1. SCOPE

1.1 Application

1.1.1 This Standard Specification defines the general requirements for the design, construction, supply, testing, installation and commissioning of Electronic Control & Instrumentation installations for Industry.

1.2 General Requirements

1.2.1 All Electronic Control & Instrumentation equipment shall be housed in dedicated control panels or enclosures conforming to the South African National Standard (SANS) for Control Gear as listed below.

1.2.2 The completed Assembly shall incorporate all components and equipment necessary to reliably achieve the functionality defined in the Project Specification and works or plant Control Philosophy.

1.2.3 All materials, components, and equipment used in the manufacture of the Assembly shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification contains standard amendments and requirements, which shall be applied to the referenced statutory and national standards. The project-specific requirements are provided in the Project Specification, which shall be read in conjunction with this Specification.

2.1.2 The design, construction, installation, inspection, testing and commissioning of the Assembly shall comply with all relevant statutory regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.

2.1.3 The Manufacturer shall follow an approved, auditable quality assurance system covering the design, construction, programming, configuring, inspection and testing of the Assembly.

2.2 Statutory Requirements

2.2.1 The Assembly as manufactured, and as installed on site, shall comply with the following:

a) Occupational Health and Safety Act of 1993

b) Manufacturer's specifications and installation instructions

2.3 Reference Standards

2.3.1 The Assembly and all its constituent components shall comply with the latest published edition of all relevant national standards, including the following:

Table 1 Reference Standards

SANS Number	Description
SANS 1973	Low-voltage switchgear and controlgear Assemblies
SANS 60204	Safety of machinery - Electrical equipment of machines
SANS 60439	Low-voltage switchgear and controlgear assemblies
SANS 61000	Electromagnetic compatibility (EMC)
SANS 61643	Surge Protection for Low-voltage AC and DC power supply systems, electronic systems, signalling systems and communication devices
SANS 62103	Electronic equipment for use in power installations
SANS 62305-4	Protection against lightning - Electrical and Electronic systems within structures
SANS 60950-1	Information Technology Equipment Safety - General Requirements
SANS 10142-1	The wiring of premises, Part1 - Low-voltage Installations

3. CONSTRUCTION REQUIREMENTS OF ELECTRONIC ASSEMBLIES

3.1 General

3.1.1 Electronic Assemblies shall be designed and constructed to facilitate inspection, cleaning, repair and maintenance and to ensure absolute safety during operation, inspection and maintenance. The Electronic Equipment manufacturer's requirements for enclosure cooling and ventilation of the equipment shall be adhered to at all times.

3.1.2 The arrangement of all circuit components / functional units shall be to the approval of the Engineer.

3.2 Enclosures

3.2.1 Assemblies shall be constructed of materials capable of withstanding the mechanical, electrical and thermal stresses to which it may be subjected and the environmental and operating conditions likely to be encountered in normal service.

3.2.2 All panels and enclosures shall be vermin and dust proof and the minimum degree of protection shall be:

Table 2 Minimum levels of ingress protection

Location	Description	Minimum rating
Indoor	Clean, dry areas (e.g. inside switch rooms or control rooms)	IP44 (doors closed) IP2X (inter-compartment & doors open)
Outdoor	Located outside of buildings in double clad outdoor weather proof enclosures	IP65 (doors closed) IP2X (inter-compartment & doors open)

3.2.3 Where heat is generated within the enclosure, it shall, where possible, be designed to dissipate naturally from the enclosure surface. Where this is not possible, ventilation openings shall be provided that maintains the highest practicable IP rating of the enclosure, subject to a minimum of IP42. Where cooling air is drawn into the enclosure, dust filters shall be provided.

3.2.4 Particular attention shall be given to the ventilation of outdoor mounted boards, to eliminate build-up of excessive heat inside the boards caused by solar radiation or internal heat generation. If the internal temperature rise is within 20 % of the upper scale of the manufacturers specification for the equipment during any time of the day or year, panel coolers shall be provided as detailed in the project Specification.

3.2.5 All the surfaces of the enclosure, and of its constituent equipment and components shall be suitably protected against the effects of any likely atmospheric corrosion present at the operating location.

3.2.6 Purpose-made gland plates shall be protected against corrosion by electro-plating, galvanising, or be made of stainless steel which shall not be painted.

3.3 Construction

3.3.1 Free-standing electronic enclosures shall be constructed from steel with a structural frame permanently clad with side plates, so as to provide a structure that is rigid with all doors and covers removed, and such that it will not deform during transportation or installation. The enclosure doors and covers shall themselves be suitably braced so as to be rigid and not deform or flex when fully equipped and handled.

3.3.2 The minimum metal thickness of the enclosure's constituent parts shall be as follows:

a)	External cladding:	2.0 mm
b)	Internal partitions:	1.6 mm
c)	Doors:	2.0 mm
d)	Gland plates and component mounting plates:	2.0 mm

3.3.3 Freestanding Assemblies shall be mounted on and bolted to a rigid hot-dip galvanised steel 100x50x6 mm channel iron base.

3.3.4 Wall mounted Assemblies shall be bolted to walls on concrete structures via a hot dip galvanise channel iron using spring nuts and washers with the channel iron bolted to the wall with concrete anchor bolts.

3.3.5 The maximum height of any Assembly (including its base) shall be 2100 mm above finished floor level. No equipment shall be installed higher than 1900 mm above finished floor height, neither shall any equipment, other than cable glands and inter panel control wiring be installed lower than 300 mm above finished floor level.

3.3.6 Enclosure single doors shall have vertical hinges mounted on their left hand side, be limited to 800 mm width, and all doors shall have an angle of opening that is limited to 95 degrees. Where specifically agreed with the Engineer, a compartment single door may be hinged on the right hand side if this is beneficial to the room and equipment layout. Panels wider than 800 mm shall be fitted with dual doors that shall open in wardrobe style, such that the second door is interlocked with the first.

3.3.7 Doors and any covers shall be fixed to the enclosure using captive bolt type fasteners, and each hinged door shall be capable of being removed, following disconnection of any electrical and earthing connections to components mounted on the doors. Compartment doors shall be provided with securing catches which can be locked with a padlock.

3.3.8 Doors shall include a full-length safety glass window with rubber gasket such that the internal electronic equipment status can be observed without opening the door. Where an HMI, pushbuttons, selector switch or indication lamps will be fitted to the door, the glass window will be placed below the equipment over the full remaining length of the door.

3.3.9 The Assembly shall be constructed for front and rear access unless otherwise specified in the Project Specification. Where the Assembly shall be designed for front access only; i.e. it shall be possible to gain access to every component, item of equipment, busbar and cable from the front (or for busbars, the top) of the enclosure; whether for maintenance or for replacement.

3.3.10 Fixings for components, component mounting plates, etc. shall not penetrate another compartment containing live parts. Only threaded fasteners shall be allowed and no components shall be fixed with rivets or self-tapping screws.

3.3.11 All components, wiring, labelling, etc., shall only be located within compartments on a removable mounting plate, and in such a manner that facilitates easy inspection, maintenance, or removal and replacement, and without necessitating the removal or dismantling of any other components or wiring, or the use of special tools.

3.3.12 All Assemblies shall make provision for have at least 15 % spare unequipped space complete with mounting rails and wire ways for future extensions.

4. INTERNAL WIRING AND FIELD CONNECTIONS

4.1 General

4.1.1 All wiring within the Assembly shall run directly between terminals, without any joints or other connections. Wiring shall be carried out using multistrand, single-core PVC-insulated copper conductor, 660/1 000 V grade (minimum), to SANS 1507, sized and derated where required for the currents to be carried. Single-strand conductor shall not be used and no conductor shall be less than 0.75 mm² cross-sectional areas.

4.1.2 Wiring shall be tinned if and as called for in the project Specification.

4.1.3 Field wiring connections will be identified using the field device tag references. This information will be provided by the Engineer, and the Contractor shall use these field identifiers when identifying the signal field terminations.

4.1.4 Wiring layout shall permit alterations to individual circuits without requiring shut down of the complete Assembly.

4.2 Wire ways inside Assembly

4.2.1 All wiring shall be routed in PVC cable trunking wire ways with snap-on covers and shall be sufficiently sized and properly placed in order to provide a neat and manageable internal wire routing system.

4.2.2 All wiring and cabling entering or leaving a compartment or passing through a partition shall do so via a permanently fixed PVC bush.

4.2.3 Wiring between components shall be:

a) carried out in a neat and systematic manner

b) contained in PVC trunking

c) run to panel doors in PVC spiral wrapping

4.2.4 Any wire containment system shall securely locate the wiring, and provide 25 % spare capacity on completion. Wire ways shall have furthermore sufficient space to enable the installation and removal of any wire without the need to remove any other wire, cable or component. Wire ways shall incorporate adequate facilities to locate and support the wires and cables.

4.2.5 Wiring on doors shall be similarly supported, and shall be provided with support and protection across the door to enclosure side wall transition, whilst permitting the door to be fully opened without straining the wiring. Wiring system accessories shall not be flame retardant and not deteriorate with heat.

4.2.6 Wiring shall be segregated according to need; circuits that enter the compartment without isolation shall be separately segregated and loomed with spiral wrapping and identified. Control circuits shall be wired in twisted pairs or screened cables, and together with data network cabling, shall be physically segregated from power circuits by barriers. Where lightning and/or surge protection measures have been implemented to protect individual circuits, these circuits shall be segregated from the wiring of other unprotected circuits.

4.2.7 Wire ways or chambers shall not contain any equipment or components.

4.2.8 Where field cables are terminated other than in the base of the enclosure, cable-ways or cable chambers shall be provided to transport the cables through the enclosure to the compartment or cable box at which they are glanded or terminated.

4.3 Gland Plates

4.3.1 All field cables and wiring shall enter the enclosure through gland plates, which shall be located so as to facilitate the spreading of cable cores.

4.3.2 Gland plates shall be rigidly supported and maintain the IP rating of the enclosure.

4.3.3 Gland plates for bottom access cabling shall be located at least 300 mm above the finished floor level and shall be an integral part of the construction of the enclosure.

4.4 Identification

4.4.1 All wires shall be identified at both ends using colour coded alpha-numeric ferrules within a compartment.

4.4.2 Where a circuit includes a PLC I/O point, the I/O point identification shall follow through from the PLC card to the first component within a remote compartment.

4.4.3 Components and wiring shall be installed such that the identification of every wire is clearly visible and readily accessible on completion of the Assembly installation at site. Horizontal wiring identifiers shall be read left to right, and vertical wiring identifiers shall be read bottom to top.

4.4.4 All conductors shall be identified in conformity with the approved circuit and connection diagrams. No number shall be used more than once in each panel except where electrically identical.

4.4.5 Wires/conductors shall have the same number on either end of the wire and all wires which are electrically identical shall have the same wire number.

4.4.6 Circuit wiring shall be coloured in accordance with the clients requirements as detailed in the Project Specification.

4.5 Termination

4.5.1 Wiring shall be terminated using crimped cable ends, lugs or any other approved method that is appropriate for the conductor size and type of termination. All of the strands forming the conductor shall be connected at the point of termination. Soldered connections shall only be used on electronic equipment where it is not practicable to use any other termination method.

4.5.2 All wiring entering or leaving a compartment shall do so via screw type terminal rails, with the exception of specialised signal or data circuits, which may be cabled directly to dedicated connections on electronic equipment located at the periphery of the component mounting plate.

4.5.3 No more than two wires shall be connected to any one side of a terminal. Where it is necessary to connect adjacent terminals together, proprietary jumper bars or combs shall be used.

4.5.4 Spare cable cores shall be terminated at both ends or tied back, but shall not be cut short.

4.5.5 All terminals shall be protected to IP2X, including stud type terminals; which shall be shrouded to achieve this rating.

4.5.6 Terminals shall be segregated according to function and operating voltage; by grouping or by terminal rail mounted partitions or barriers and all circuit terminal rails shall include 10 % spare space.

4.5.7 Terminals shall face the compartment door for ease of connection.

4.5.8 Terminals shall be located and spaced so as to enable the easy disconnection and reconnection of conductors, whilst providing sufficient space for the looming and spreading of cable cores. Where practicable, the layout of terminal rails shall be such that cores from the same field cable are not split between non-adjacent groups of terminals.

4.5.9 All wiring of external connections shall be brought out to individual terminals on a readily accessible terminal block.

4.6 Junction Boxes

4.6.1 Equipment and junction boxes shall be of steel, aluminium or GRP construction or as specified in the Project Specification.

4.6.2 All steel Junction Boxes shall be primed, undercoated and gloss finished with epoxy or polyurethane paint.

4.6.3 All boxes shall have a box name or number on the cover.

4.6.4 Junction Boxes for indoor use shall be at least IP 54 rated and Junction Boxes for outdoor use shall be at least IP 65 rated.

4.6.5 Junction boxes shall provide the facility to fully terminate the entire multi-core cable entering the box.

4.6.6 Junction Boxes which are exposed to the sun, shall be installed south facing otherwise with an additional shading cover.

4.6.7 Junction Boxes shall be mounted with their sides true vertical and horizontal.

4.6.8 Junction Boxes for instrumentation integral cables shall be of the round screw lid GRP or Aluminium type with two, three or four gland ports and shall be supplied fully equipped with screw terminals on a DIN rail inside and appropriate compression glands to fully gland and terminate the incoming and outgoing cables to maintain the required IP rating.

5. EARTHING

5.1 General

5.1.1 The complete electronic installation shall be earthed in accordance with the latest issues of the applicable South African National Standards (SANS) and any applicable bylaws of the local supply authority as well as any relevant client specific requirements as stipulated in the Project Specification.

5.1.2 The electronic installation shall incorporate a protective (power supply) earth system and a separate functional (instrumentation / data communications) earth system both of which shall be connected to the overall low-voltage installation's main earth system.

5.1.3 The Contractor shall familiarize himself with the Low-Voltage installation's earthing system at the plant or works (existing or installed by others) in order to tie the electronic earth system to the main earth system in compliance with the chosen earthing concept as defined in SANS 10142-1.

5.1.4 All functional earth conductors shall be insulated conductors providing a "clean earth" arrangement.

5.2 Earth Bars

5.2.1 Each Electronic Assembly shall include a separate protective Earth and functional earth bar. Earth bars shall:

a) be manufactured from high conductivity copper (tinned if and as called for in the Particular Specification)

b) be located in a safe and easily accessible position

c) have facilities for connection to the main incoming earth terminal (located in the LV switchroom / control room or at a local earth electrode system)

d) be rated and tested for the Assembly's expected maximum electrical supply fault current

e) be securely connected in each panel or cubicle with the protective earth bar bonded to the enclosure and the functional earth bar insulated from the enclosure

5.2.2 Provision shall be made for the connection of the following conductors to the fixed portions of the earth bars via drilled holes, cable lugs and fixing bolts:

a) electrical installation protective earth conductors internal and external to the Assembly

b) functional earthing conductors internal and external to the Assembly

c) equipotential bonding conductors internal and external to the Assembly

d) other equipment protective conductors external to the Assembly

e) an additional 2 off spare terminations

5.2.3 All metallic non-current carrying parts of the Assembly shall be bonded together and connected to the Assembly protective earth bar.

5.2.4 The following assembly parts shall be directly connected (bonded) to the protective earth bar by earthing conductors or braided straps with a minimum cross sectional area as defined in SANS 10142-1:

a) enclosure door (if it incorporates any equipment such as an HMI, pushbuttons, selector switches or indication lamps)

b) any removable electronic equipment covers

c) component / equipment mounting plates, rails and earth terminals

d) PLC / PCS and Instrumentation enclosure chassis plates

5.2.5 Surge protection earths; e.g. direct connections from lightning protection units. The following circuits shall be connected to the functional earth of the relevant assembly by earthing conductors with a minimum cross sectional area as defined in SANS 10142-1:

a) 'clean' earths from instrumentation circuits and equipment

b) functional earths; e.g. from telecommunications equipment

5.2.6 Each Assembly's earth terminals or bars shall be separately connected directly back to the Assembly main earth bar with earthing conductors of a minimum cross sectional area as defined in SANS 10142-1.

5.2.7 For installations that include control rooms or computer rooms (housing Information Technology and Telecommunications equipment), the functional earth shall consist of an earthing busbar and/ or earth mat as directed by the Project Specification.

5.2.8 Earthing busbar design and sizing shall comply with Annexure N of SANS 10142-1 and be rated as stipulated in the Project Specification and Technical Data Sheets.

5.2.9 Computer and Control Room earth mats shall be designed taking into account the expected equipment operational frequency ranges and equipment densities according to SANS 61000-5 Part 2.

5.2.10 Each Electronic Assembly in the Control or Computer Room shall be bonded directly to the earth busbar or earth mat via the shortest route and the earth busbar and/ or mat shall be separately connected directly back to the Assembly main earth bar, all with insulated earthing conductors of minimum cross sectional area as defined in SANS 10142-1.

5.2.11 If specified in the Project Specification, separate earth bars or studs shall be provided for connecting equipment requiring an intrinsically safe earth directly to the main incoming earth terminal. If required, such earth bars or studs shall be located adjacent to the equipment requiring an intrinsically safe earth, as directed by the intrinsically safe equipment supplier.

5.2.12 Where zener diode safety barriers are contained within an Assembly, they shall be separately and directly connected to the main earth bar via double earthing conductors; These conductors shall be clearly identified as intrinsically safe earths.

5.3 Earth Electrode

5.3.1 Where a protective Earth Electrode does not exist or has NOT been installed as part of the Low-voltage installation by others, this contract shall include for the supply and installation of a suitable main earth electrode as stipulated in the Project Specification and the Engineering Standard SPE-EE-0010 "LV and MV Earthing".

5.3.2 A separate Electronic or "clean earth" electrode will not be accepted.

5.4 Earthing of Communication and Signal Cables

5.4.1 For the purpose of this specification, "communication" cables shall mean all data and network communication and transmission cables, and signal cables shall mean all instrument voltage or current loops and sensor cables.

5.4.2 The “common” or “reference” conductor of all signal cables shall be connected to the protective earth of the Electronic Assembly in order to ensure the safety of the equipment as well as the signal’s integrity.

5.4.3 Communications cables shall be connected to the functional earth to protect them against the negative effects of electromagnetic, inductive and capacity coupling so that noise on cables is limited to an absolute minimum preventing communication faults from occurring.

5.4.4 This shall be achieved by shielded (double screened) twisted conductor pair cables with the outer screen of all communication cables earthed with the aid of soldered termination and cable lugs at the source (electronic assembly) only. The route that the screened wire follows to the electronic assembly’s functional earthing point shall be as short as possible.

5.4.5 Where communications cables carry high frequencies (above 1 MHz) the screen shall be earthed to a parallel running functional earth conductor of minimum 2.5 mm^2 insulated copper conductor (or earth grid/ mat) in order to limit the effects of high frequency resonance.

5.4.6 When communications or signal cables are installed where there is a significant risk of high frequency interference; (e.g. in signal circuits connected to equipment containing power electronics), they shall have their screens capacitively connected to earth as directed by the specific equipment supplier.

6. LIGHTNING AND SURGE PROTECTION

6.1 General

6.1.1 The complete Electronic installation shall be protected against transients, surges and induced interference from nearby electrical cables and / or equipment as well as mechanical equipment and related structures.

6.1.2 The protection shall ensure that the electronic equipment integrity is maintained and remains operational, or otherwise isolates the equipment from the transients, surges or interference in such a manner that it can be returned to operational use after the event.

6.1.3 Protection measures shall be provided as described below.

6.2 Earthing for Lightning and Surge Protection

6.2.1 The Lightning Protection System (LPS) shall be designed and selected to mitigate the expected lightning intensity on the site and as defined in the Project Specification.

6.2.2 Unless stated otherwise in the Project Specification, the Lightning protection system shall be assumed to be existing or installed by others under a separate Contract and the Electronic Assembly lighting protection measures shall tie into that system.

6.2.3 The Contractor shall familiarize himself with the system (existing or new) in order to tie into the system in the appropriate manner and as described in SANS 10142-1 and SANS 62305.

6.2.4 Proper bonding of all Electronic Assembly enclosures to the protective earth as described in Section 5.2 above, shall ensure protection against lighting induced electromagnetic surges impinging on the electronic assembly and all its internal components. All components supplied and installed within the Electronic Assemblies shall in any event be EMC compliant according to IEC 61000.

6.2.5 Proper shielding and bonding of communications and signal cable shields to the functional earth, as described in section 5.3 above, shall ensure protection against lighting induced electromagnetic surges impinging on data communications and signal cables to and from the Electronic Assemblies.

6.2.6 For the protection against lightning induced surges on power, communications and signal connections to and from the Electronic Assembly components, other assemblies and field devices, either isolation transformers, optical isolation, metal free fibre optic cabling or a system of coordinated surge protection devices (SPDs) connected to all conductors shall be used depending on the location of the equipment in the relevant lightning protection zones (LPZ), the expected surge intensities and the electronic equipment's impulse withstand ratings; all as defined in SANS 62305.

6.2.7 Where more than one SPD module is used at any one location or within any one Assembly, these shall be grouped together in one physical location.

6.2.8 The SPD modules shall be installed as close as possible to the Assembly's protective earth bar and shall be bonded to the protective Earth bar with a stranded copper conductor of minimum 6 mm^2 for Class II SPD (power) and 1 mm^2 for Class III SPD (signal and data).

6.2.9 Each surge protection module shall be individually connected to the earth bar using the shortest route possible.

6.2.10 All surge protection modules shall be DIN rail mountable and use screw terminals for termination of conductors.

6.2.11 All SPDs shall comply with the requirements of SANS 61643-1 and shall bear the SABS mark.

6.3 Surge Protection

6.3.1 The lightning and switching transients and the regulation of the available 230VAC supplies to the Electronic Assemblies shall be regarded as those relevant to an industrial supply.

6.3.2 The Tenderer shall therefore allow for additional surge suppression and voltage stabilisation equipment if this is required to protect his offered equipment and/or to guarantee its correct and reliable operation.

6.3.3 Equipment that is connected to signal lines of any type between separate LPZs shall, be surge protected to survive twenty 8/20 µs current impulses with maximum amplitude of 10 kA when applied in common mode between the signal lines connected together and to the system protective earth.

6.3.4 In the case where surge protection equipment is factory fitted into the electronic equipment being offered, but is found to be inadequate to meet this specification, additional external surge protection shall be provided.

6.3.5 Equipment which is connected to signal lines of any type between equipment within a common LPZ and for which the signal cable is longer than 30 m, shall be protected as above, except that the maximum amplitude for the common mode test shall be 2 kA and the maximum amplitude for the differential mode test shall be 500 A.

6.3.6 Surge protection devices shall be chosen in such a way that the protected circuit shall still function to specification in spite of the introduction of series and/or shunt impedances by the protecting devices.

6.3.7 Surge protection shall encompass, but not be limited to the following requirements:

a) On all analogue/digital input and output circuits - suitable signal surge protection units with appropriate ratings as defined by the relevant SANS 61643.

b) On all mains power supply circuits - suitable power supply protection modules as defined by the relevant SANS 61643.

c) On all telephone lines - Telkom approved protection network, containing gas arrestors, inductance's, transorb type arrestors and 600 Ω / 600 Ω isolating transformers. Loop and ringing current circuits shall be optically isolated.

d) Surge arrestors shall be installed on all phases of the electrical power supply at the input terminals to each equipment cabinet.

e) Where external lines have to interface with sensitive electronic equipment, such as computers and associated peripheral equipment, suitable opto-isolators with an isolation level of at least 5 kV shall be installed.

f) All co-axial cables shall be provided with in-line surge suppressors.

g) It is not anticipated that the stated equipment will, used on their own, necessary provide the required level of protection and the Contractor shall implement additional measures deemed necessary to achieve the required protection level.

h) The Engineer may allow the use of alternative types of surge arrestors, provided that equivalent or superior protection levels will be achieved. SABS and/or CSIR test reports to substantiate claims shall be submitted to the Engineer prior to installation for the alternative equipment.

i) The connecting cable between electronic units shall have a continuous screen (not bridged) which shall be earthed at both ends.

6.3.8 Power supply protection modules shall be used to protect the incoming power supply to the system and for mains supplied stations shall have the following characteristics:

a) The unit shall be rated to operate at a voltage up to 280V AC/DC.

b) The nominal discharge surge current (8/20 μs-wave) shall be greater or equal to 15 kA.

c) The maximum discharge surge current shall be greater or equal to 40 kA.

d) The unit shall react in less than 25 ns.

e) The unit shall be equipped with a visual indication to indicate a fault within the unit or if it is disconnected from the supply.

f) A fault within the unit shall not affect the operation of the power supply.

6.3.9 A power supply protection module shall be made up out of two units with the above characteristics the one unit connected between live and neutral and the other between neutral and earth. The earth shall be connected to the lightning protection interface earth bar via the shortest possible route and shall have a conductor cross sectional area of not less than 25 mm².

6.3.10 Signal SPD modules shall be of a pluggable design, with the decoupling elements arranged in the plug base element. The decoupling elements shall not be affected by the presence or absence of the protection plug and the removal of the protection plug shall not break the signal circuit.

6.3.11 It shall be possible to remove and test the protection unit on site using a portable test set.

6.3.12 Signal SPD modules shall be designed for two conductor floating ground circuits and shall offer individual signal line to ground as well as signal line to signal line protection.

6.3.13 The protection plug shall have the following basic elements and shall function as follows:

a) It shall be provided with a gas discharge tube that will absorb the largest part of the energy of an over-voltage impulse.

b) It shall be provided with a solid state Zener diode combination which will clamp the output voltage before the gas discharge tube is activated.

c) It shall be provided with diodes that will limit the capacitance between lines in order to limit the interference of high frequency signals.

6.3.14 The protection unit shall be able to contain over voltages to a maximum of 30 V AC peaks between any of the output terminals and earth or between the two output terminals.

6.3.15 Note: The over voltage referred to above, is defined as an over voltage with a rise time of 10 μs, a peak voltage of 800 V AC, a short circuit peak current of 100 Amp and a voltage down-time linear with a down-time of 50 % of the peak value after 100 μs. Such an over voltage is generally accepted in the telecommunications industry and represents the maximum energy and typical wave forms that are induced on twisted pair communications lines in the vicinity of lighting.

6.3.16 Copies of Type test certificates of the offered protection units shall be submitted to the Engineer for approval.

6.3.17 Terminal strip arrangement between RTU and field equipment shall be as follows:

a) Two separate terminal strips shall be provided, one for digital signals and one for analogue signals. The terminals shall be grouped per field device and secondarily by function (i.e. all inputs together and all outputs together per field device).

b) All digital inputs shall be powered by the electronic device's power supply and all digital outputs shall be field powered. All digital signals shall be protected by means of pluggable signal circuit protection units. The surge protection units shall comply with the relevant SANS 61643.

c) All analogue inputs will be field powered. All analogue inputs shall be protected by means of pluggable signal circuit protection units. The surge protection units shall comply with the relevant SANS 61643.

d) In addition to the above, all outgoing and incoming signal lines shall be protected by means of knife disconnect terminal blocks with gas-filled surge arrestors between signal lines.

e) The pluggable signal protection unit may serve as the terminal block for connecting outgoing cables.

f) All digital output signals shall be interfaced by means of interposing relays with a single pole change-over contact. The contacts shall be rated for a minimum of 2 A, 230 V at a power factor of 0,8.

6.3.18 The terminal arrangement as detailed above shall have at least 25 % spare space after all incoming cables (including spare cores) have been terminated.

7. SIGNS AND LABELS

7.1 General

7.1.1 Safety signs and labels shall be provided wherever necessary in relevant languages so as to unambiguously communicate safety and functional guidance to any person who may operate the Assembly or otherwise come into contact with any part of the electrical or electronic system forming a part of the Assembly, and shall be provided for the specific identification of every component contained within the Assembly.

7.1.2 Signs and labels shall be located in such a manner that:

a) it is obvious as to the nature and location of the hazards or component(s) to which they relate

b) when mounted on any enclosure cover or plate, there is no possibility of that cover or plate being interchanged with any similar item on that Assembly or on any other Assembly supplied to the same site

c) they are not fixed to easily removable parts (e.g. trunking covers, etc.), unless their purpose is to warn of the consequences of removing a removable part

d) they are at all times adjacent to the item to which they refer, and accommodate situations where components could be moved along a DIN mounting rail

e) they will not be obscured by any equipment, components, or wiring, etc.

f) they are legible and will remain easily read throughout the life of the Assembly

7.1.3 Signs and labels shall be securely and permanently fixed using an appropriate number of corrosion resistant, mechanical fixings (double sided adhesive tape will not be accepted). The fixing of labels, safety signs and notices shall not affect the IP rating of the Assembly.

7.1.4 Short individually fixed labels covering several items only, shall be used in lieu of long multi-legend labels; e.g. above a row of indicator lamps.

7.1.5 Safety signs and labels shall be of such size that the legend thereon is clearly legible from the operating position (or a 3 m distance), and the pictograph and its accompanying text shall be chosen so as to provide the appropriate communication in an explicit and unambiguous manner.

7.1.6 Safety signs and labels fixed to the outside of the enclosure shall be manufactured from 1.5 mm thick anti-reflective polycarbonate with the legend reverse screen printed, or alternatively from 3 mm thick bevel-edged clear perspex rear engraved with black characters. Internal labels may be manufactured from a laminated plastic material which shall normally provide a black legend against a white background. Where specifically agreed with the Engineer, internally mounted labels and charts, e.g. for distribution boards, etc., may be of permanently printed plastic, plastic laminated thin card, or thin card protected behind perspex.

7.2 Safety Signs

7.2.1 As a minimum, safety signs shall be fitted to removable covers over live connections, and to doors of compartments containing:

a) incoming supply cable termination points

b) functional units incorporating capacitors

c) hazardous equipment such as fibre optic laser communications

d) equipment located in a ‘safe area’ but associated with certified apparatus located in a hazardous area; a sign shall also be fitted at the safe area cable termination rail.

7.2.2 A safety sign identifying the operating voltage shall be placed in any compartment where there is equipment, components, or wiring, that can be energised at above extra low voltage.

7.2.3 Where there is no suitable standard symbol or pictograph, an application specific sign may be produced using simple and appropriate symbols, pictographs, and text, to indicate the hazard in a simple and straight forward manner that is acceptable to the Engineer.

7.2.4 Multipurpose signs shall be used where there is a need to communicate multiple hazard messages.

7.3 Labelling

7.3.1 The text of every label, excluding individual internal component identification labels, shall be as agreed with the Engineer.

7.3.2 Every Assembly shall be provided with a name plate detailing the following:

a) Manufacturer’s name or trademark

b) Manufacturer’s contact details

c) Manufacturer’s type designation, serial / identification number

d) Date of manufacture

e) IP rating

7.3.3 An application name shall be prominently displayed on the Assembly, as detailed in the Project Specification.

7.3.4 The material used shall be selected having regard to the size and fixing methods of the label and the label shall not warp in service. Labels mounted on the outside of the Assembly shall rectangle in form and be manufactured of either:

a) Laminated plastic, engraved so as to produce black letters on a white background

b) Engraved sandwich board ("Traffolyte", "Darvic" or equal)

c) Reverse engraved acrylic material ("Perspex") with filled letters and reverse sprayed

7.3.5 For outdoor applications (where specified in the Project Specification) labels shall be brass or aluminium (with letters filled in black), lightly sanded with fine grit paper and clear lacquered.

7.3.6 Labels for door mounted components and labels used inside the Assembly shall be to the same standard or may alternatively be printed using an approved, propriety system.

7.3.7 Text characters shall be uniform in height, in upper case (except where standard abbreviations of units are used, e.g. kWh, kVA, etc.) and of the following minimum dimensions:

a) application labels: 8 mm

b) compartment designation labels: 6 mm

c) information or warning labels: 6 mm

d) component identification labels: 3 mm

7.3.8 All components shall be clearly labelled. Internal components shall be clearly identified by individual labels to indicate the equipment to which they relate. The component identification labels shall correlate with the Assembly drawings and documentation. If this is not practical due to space restrictions, common labels (e.g. diagrams may be used).

7.3.9 PLC / PCS and Remote Input / Output cards shall be fitted with printed I/O address labels including the TAG numbers where it is practical to do so. Alternatively a plastic laminated label card shall be provided and included in a steel pocket on the inside of the assembly door.

8. INSTALLATION REQUIREMENTS

8.1 Shipping

8.1.1 Assemblies shall be shipped in sections to facilitate field handling for transportation and installation. The shipped sections shall be joined together on site to form a complete unit assembly.

8.1.2 Preparation for shipment shall protect the Assembly auxiliary devices accessories, etc. against corrosion, breakage or vibration damage during transportation and handling.

8.1.3 All parts shall be clearly and permanently marked to facilitate disassembly and packing for transport. Instructions shall be provided for reassembly of sections on site or accompanied by a qualified representative from the Assembly Manufacturer.

8.2 Transportation and installation

8.2.1 The Contractor shall be responsible for disassembly, packaging, delivery to site (including loading and offloading) as well as reassembly of all equipment on site.

8.2.2 The Contractor shall provide timely information regarding all specialized handling and storage requirements for equipment to be transported and /or handled on the site until finally installed in the operating location.

9. FUNCTIONAL DESIGN

The Engineer will provide the Contractor with the following information, which shall form the basis for the Contractor's design of the Assembly:

9.1 The Project Specification

The Project Specification detailing all project specific requirements.

9.2 Motor and Instrumentation Table

A Motor and Equipment List, and a Instrumentation list providing a list of all externally connected equipment, their function, rating and purpose. It provides the Engineer's estimate of each load's kW rating and the starting method, the process measurement, local visual indication and the requirements for manual, automatic and local control to be implemented.

9.3 I/O List

An I/O List detailing the Engineer's estimate of the input and output signals (analogue and digital) required for motor control, instrumentation and general control purposes.

9.4 Technical Detail Sheets

The Technical Detail Sheets used for Tender purposes, which shall be completed by the Contractor and verified by the Engineer for compliance to the Project Specifications, so as to detail the project and product specific requirements for each Assembly and its constituent functional units before procurement and manufacture.

9.5 Control Philosophy

The Control Philosophy detailing the Engineer's intent for functionality of the plant or works and all automation, control and instrumentation systems.

9.6 Cable Block Diagram

Cable block diagram(s) indicating how the components of the Assembly are to be connected to the motors and instrumentation for the process that must be controlled.

9.7 Assembly general arrangement drawing

A proposed layout providing the Contractor with the Engineer's intent for the layout and relevant sizing of the Assembly.

9.8 Building arrangement and equipment location drawing

A drawing indicating the plant layout, control equipment location and proposed location for the Electronic Assemblies.

9.9 Contractor's Design

The Contractor shall take the Engineer's design and complete it for the equipment offered during tender and approved for construction. Documentation and Drawings to be produced and submitted for approval are described in Section 10 below.

10. TESTING AND COMMISSIONING

10.1 General requirements for testing

10.1.1 On completion of manufacture, the Assembly shall be subjected to a factory acceptance test (FAT), comprising the Manufacturer's in-house tests, and the repeat tests witnessed by the Client and the Engineer. All testing shall include both Hardware functional and Software simulation testing.

10.1.2 Once the witnessed FAT has been carried out, signed off, and any remedial works have been completed and re-tested, the Assembly is ready for delivery to site. Once erected in position, the Assembly shall be subjected to a witnessed site acceptance test (SAT).

10.1.3 Once the SAT has been carried out and signed off, any remedial works shall be completed and re-tested. Plant installation and site cabling will then be carried out by others, and on its completion, witnessed commissioning shall commence.

10.1.4 The manufacturer shall allow for each test (apart from in-house tests) to be witnessed by both the Client and the Engineers simultaneously. An individual testing activity shall not be considered to have been completed until results have been recorded, and it has been signed off by the Engineer.

10.1.5 The manufacturer shall provide the Client and Engineers with all reasonable facilities, including testing staff and test equipment, to carry out the inspections and tests, and to check the Assembly for compliance with all of the Client's requirements.

10.1.6 The manufacturer shall ensure that all testing is carried out in a safe manner and shall be responsible for all measures in accordance with the Occupational Health and Safety Act.

10.1.7 During development, software may be electronically verified apart from the Assembly it controls using a simulation / diagnostic package; notwithstanding this, control systems shall be witnessed tested with the software loaded into the programmable devices, and with simulation of the physical I/O devices to equipment such as MCCs.

10.1.8 Where the Assembly incorporates equipment requiring special testing facilities or procedures, the manufacturer shall ensure that appropriate resources are available; including where necessary, representatives from the equipment Manufacturer.

10.2 Factory acceptance tests (FATs)

10.2.1 The manufacturer shall perform his in-house works tests in accordance with the proposed FAT procedures, and shall satisfy himself as to the accuracy and quality of the manufactured Assembly in accordance with the accepted design. Once the in-house FAT has been carried out, signed off by the manufacturer, and any remedial works have been completed and re-tested, the tests shall be repeated and witnessed by the Client (if required) and the Engineer.

10.2.2 When testing the performance of any software, it shall be demonstrated using the hardware intended to be incorporated within the Assembly, and where this is not possible appropriate operator interfaces, programming units, and terminal units, etc. shall be provided. Where it is necessary to demonstrate an interface with a piece of unavailable equipment to be supplied by others, appropriate means to replicate that equipment and simulate the interface shall be provided.

10.2.3 The Engineer preserves the right to cancel and postpone tests if he finds that the Contractor has not made reasonably sure that the test will be successful. Any extra costs incurred shall be borne by the Contractor.

10.3 Site acceptance test (SAT)

10.3.1 All equipment and every circuit that was altered or disturbed subsequent to the completion of the FAT, or for shipping and site erection, shall be specifically re-tested for integrity and functionality.

10.3.2 During the SAT, all cables and terminations shall be subjected to continuity and short circuit tests.

10.3.3 The process functionality of each aspect of the control system and its operator interface shall be demonstrated, including the correct operation of all I/O and network links external to the Assembly or not otherwise tested during the FAT.

10.4 Commissioning and other tests

10.4.1 The Contractor shall ensure that the Assembly manufacturer provides assistance during the commissioning of the Assembly, whereby the functionality of the Assembly and its control system and software shall be proven. During commissioning the Contractor shall make such adjustments, software modifications, and circuit changes, as are deemed necessary to provide the level of plant functionality and performance specified by the Client. All such changes shall be immediately incorporated into the 'As-Built' documentation and the Operating and Maintenance Manual, by the Contractor.

10.4.2 The Contractor shall provide a comprehensive commissioning checklist that shall be used to record the Electronic equipment and Control gear commissioning and tests results, and make provision for formal sign-off of the installation by the Engineer and the Client.

11. DOCUMENTATION AND TRAINING

11.1 General

11.1.1 All Assembly drawings, wiring diagrams, information, and documentation shall be in English, and each item shall be identified with:

a) the Client's name and contact details

b) Client's project / scheme / contract reference title and numbers

c) the Engineer's name and contact details

d) Engineers reference numbers

e) Contractor's works / contract / order references

11.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

11.2 Drawings for Approval by the Engineer

11.2.1 The following documentation and drawings shall be submitted to the engineer prior to the procurement or manufacturing of Electronic equipment Assemblies:

a) General arrangement, typical component mounting plate layouts, and foundation plans.

b) Wiring schematic diagrams showing all equipment and components incorporated into the Assembly. Known circuitry outside of the Assembly and connected to it, shall be shown on all drawings. Drawings shall be cross-referenced using a grid / line reference system.

c) Software and configuration documentation; including logic diagrams and function block diagrams. The documentation shall be complete and annotated with purpose, function, duty, cross-references, and descriptions, etc.; sufficient to guide an unfamiliar person through the operation of the software.

11.3 Testing Documentation and Reports

11.3.1 A factory acceptance test (FAT) document shall be provided to the Engineer prior to the witnessed FAT. This documentation shall show the manufacturer's in-house test procedures and results for all items of equipment, components, hardware, and software. The document shall show hardware checks, the software simulation procedures, and their combined functional testing. It shall comprehensively and clearly show the test results of the in-house testing. The subsequent report of the FAT witnessed by the Engineer shall be appended to the contractual documentation.

11.3.2 The Contractor shall provide his own testing report template to document the FAT witnessed by the Engineer. This shall be to the satisfaction of the Engineer.

11.3.3 A site acceptance test (SAT) document shall be produced, which shall detail all tests necessary to demonstrate the functionality of the Assembly following its final erection on site. This shall include details of tests and checks on all circuits disconnected for shipping, together with any equipment, components, wiring, or software altered or incorporated into the Assembly; following the completion of the witnessed FATs.

11.3.4 All drawings, schedules, listings, and other design documentation for acceptance shall be supplied as a comprehensive and integrated package and collated into folders; unless otherwise agreed with the Engineer. Three copies of appropriate documentation shall be submitted on each occasion that agreement is sought.

11.3.5 The FAT and SIT shall each have been submitted and agreed with the Engineer, prior to the commencement of final testing and site commissioning.

11.4 Operating and Maintenance Manual

11.4.1 One copy of the draft operating and maintenance manual and spare parts list shall be provided at an agreed date; in advance of the date of the start of the final testing and commissioning SATs, for acceptance by the Engineer. Three copies of the final editions shall be provided to the Engineer by an agreed date before successful completion of final testing and commissioning.

11.4.2 The Operating and Maintenance Manual shall be bound into a suite of hard-backed ring binders, and shall be provided with an index of all drawings pertinent to the Assembly. The index shall include each drawing's origin, number, issue, status, and the Client's drawing number (where issued by the Engineer).

11.4.3 The Operating and Maintenance Manual shall include the following:

a) All design drawings and documentation relating to the Assembly; as delivered and tested.

b) 'As Built' records showing verification against stated design and installation criteria, including a schedule of all the final settings for all user adjustable equipment and components, and copies of all documentation presented and completed during the FATs, the SATs, and any other specified tests on completion.

c) Schedules of plant and equipment for each enclosure/ junction box / circuit; including a listing of the applicable standards, manufacturer, settings, type number, re-order code, etc., for each item of equipment and component included within the Assembly.

d) Manufacturers' contact details, technical information sheets for all items of equipment and components included within the Assembly. Manufacturers' catalogues may be provided subject to clear identification of the relevant components. All individual manufacturers' equipment / component test certificates and certificates of conformity, shall be included.

e) Inspection, testing, and maintenance recommendations, including detailed and specific operation, maintenance, and diagnostic data, and safe isolation information suitable for use by maintenance personnel, shall be provided for all equipment, components, and systems incorporated into the Assembly.

f) Schedule of spares provided with the Assembly, including manufacturer, description, part number, order code, and quantity.

g) A DVD with all software backups and program code used on all data control devises (i.e. PLC, HMI, SCADA, control panels, industrial networks).

h) A schedule of all installed cables, with the following information:

   i) Tag number

   ii) From equipment tag number and description

   iii) To equipment tag number and description

   iv) Circuit number (DB name, circuit breaker e.g. DB01-CB08)

   v) Size

   vi) Installed length; and

   vii) Function (e.g. "Feeding Submersible pump IW-SP-01")

11.4.4 The Operating and Maintenance Manual shall include detailed descriptions for use by the Client, on how the controlled plant and its management systems are intended to operate and be operated; under both manual and automatic control. Clear and detailed descriptions for each element of the Assembly shall be provided; and shall include system objectives, controlled plant start-up and shut-down procedures, automatic control, manual intervention, primary and secondary control routines, plant selection including duty and standby options, local and remote selections, operational and safety constraints, status information, alarms and control interfaces with SCADA / telemetry systems, fault routines, etc. In other words, the FDS shall be converted to an FD to be inserted in the O&M Manual.

11.4.5 The Operating and Maintenance Manual shall include 'as-installed and tested' information on both the hardware and software for each programmable device incorporated within the Assembly, including:

a) Overview of system operation in relation to the controlled plant.

b) System configuration.

c) Manufacturers' literature on operation, maintenance and testing of hardware and ancillaries, programming instructions, and diagnostics.

d) Hard copy program; with listings fully documented.

e) Listing of the final settings of all process dependent variables.

f) Permanent back-up copies, licensed in the name of the Client, shall be provided for all software, including operating programmes, application programs, and configuration software for all configurable devices.

g) Any interconnecting leads, protocol conversion modules, connectors, etc. necessary to connect and communicate with each programmable / configurable device to a standard portable Notebook.

11.4.6 The Manual format shall be A4 size with layout suitable for binding in A4 Level Arch type files. Drawings shall be A4 or A3 suitably folded to fit the A4 Lever Arch file.

11.5 Training

11.5.1 Electronic equipment operation and maintenance training shall form part of the overall training programme.

11.5.2 The Contractor shall conduct training courses for designated personnel in the maintenance and operation of the equipment and associated Assemblies.

11.5.3 The Assemblies shall be in a complete working order before training shall commence.

11.5.4 A training schedule, together with the name and background of the person who will perform the training, shall be submitted to the Engineer for approval.

11.5.5 Training and training manuals shall be based on the O&M Manuals.

11.5.6 Training manuals shall be delivered for each trainee with two additional copies delivered for archival at the project site. The manuals shall include an agenda, defined objectives for each course.

11.5.7 Where the Contractor presents portions of the course material by audio visual means, copies of those audio visual presentations shall be delivered to the Employer as part of the printed training manuals.

11.5.8 The Employer reserves the right to videotape the training sessions for later use.

11.5.9 The training shall include operator training and technical/maintenance training.

11.5.10 During the installation phase, a person will be designated by the Employer to be closely involved with the installation and commissioning process. The intention is not to interfere with the Contractors' installation team, but to do observation in order to obtain the maximum possible information regarding the installation, to enable efficient maintenance to be undertaken by the Employer after final hand-over and expiring of the guarantee period.

11.6 Operations& Maintenance training sessions

11.6.1 There shall be training sessions for the operation and maintenance of the Assemblies.

11.6.2 The program for the training shall include instruction for at least one day per Assembly (8 hours) instruction on-site.

11.6.3 The program shall at a minimum cover the following:

a) General system overview

b) Functional operation of the system i.e.:

i) System start-up and shut-down procedures

ii) Equipment operation

iii) System access requirements

iv) Alarms

v) Fault Finding

vi) Backup Power Procedure (if applicable)

vii) Incident Reporting

viii) Maintenance

ix) Maintenance Schedule

x) Standard Maintenance Procedures

xi) Spare Part Lists

11.6.4 Upon completion of the course, the operators should be fully proficient in the system operation and have no unanswered questions regarding the system.

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Programmable Logic Controllers (PLC)

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Contents

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1. SCOPE

1.1 Application

1.1.1 This Standard Specification defines the requirements for the design, construction, supply, programming, configuration, testing, installation and commissioning of Industrial Process Control equipment such as Programmable Logic Controllers (PLC) and Process Control Systems (PCS) as well as their interfaces to process equipment and instrumentation as well as to operator Visualization systems such as HMI and Supervisory Control and Data Acquisition (SCADA).

1.1.2 Where a package plant is offered with integral PLC or PCS this specification shall also apply and the onus is on the tenderer to qualify all deviations (if any) with his offer.

1.2 General Requirements

1.2.1 A PLC or PCS shall be provided for each area of the plant or works as listed in the Project Specification and as shown on the Control System Architecture diagram.

1.2.2 The PLC or PCS shall be provided complete with all components and peripherals necessary for it to completely control a plant or works and the architecture diagram defines the configuration of the PLC or PCS in terms of localization or centralization, local or remote inputs and Outputs (IO) and data communications interfaces, levels and paths.

1.2.3 The PLC or PCS shall be housed in a dedicated control panel or enclosure conforming to the South African National Standard (SANS) for Control Gear as listed in section 2.3 below and the Engineering Standard SPE-II-0001 - “General Electronic Installations”.

1.2.4 The completed Assembly shall incorporate all components and equipment necessary to reliably achieve the functionality defined in the Project Specification and Control Philosophy.

1.2.5 All materials, components, and equipment used in the manufacture of the Assembly shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification contains standard amendments and requirements which shall be applied to the referenced statutory and national standards. The project-specific requirements are provided in the Project Specification, which shall be read in conjunction with this Specification.

2.1.2 The design, construction, installation, inspection, testing and commissioning of the Assembly shall comply with the Engineering Standard SPE-II-0001 "General Electronic Installations", all relevant statutory regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.

2.1.3 The Manufacturer shall follow an approved, auditable quality assurance system covering the design, construction, programming, configuring, inspection and testing of the Assembly.

2.2 Statutory Requirements

2.2.1 The Assembly as manufactured, and as installed on site, shall comply with the following:

a) Occupational Health and Safety Act of 1993

b) Manufacturer's specifications and installation instructions

2.3 Reference Standards

The PLC panel Assembly and all its constituent components, equipment, configuration and programming shall comply with the latest published edition of all relevant national standards, including the following:

Table 1: Reference Standards

Standards	Description
SANS	As listed in the Engineering Standard SPE-II-0001 "General Electronic Installations"
IEC 61131 (Parts 1-8)	Programmable Logic Controllers
IEC 61499-1	Function blocks
ANSI ISA-5.06.01-2007	Functional Requirements Documentation for Control Systems
ANSI ISA-6231-2011	Automation Systems Factory Acceptance Test (FAT), Site Acceptance Test (SAT), and Site Integration Test (SIT)

3. PLC HARDWARE

3.1 General

3.1.1 PLC and PCS hardware shall be of a recognised reputable type, approved by the Engineer; from a major international supplier, with a comprehensive and established South African based technical and logistical support operation.

3.1.2 The PLC / PCS shall comprise of the following:

a) Central Processing Unit (CPU)

b) dedicated Power Supply Unit (PSU)

c) digital and analogue hard-wired input / output (I/O) cards

d) remotely connected digital and analogue I/O cards (if and where specified)

e) data communications cards and/or ports on the CPU

3.1.3 The PLC / PCS shall interface with other devices and systems as follows:

a) control circuit components, equipment, instrumentation and plant devices

b) industrial Ethernet communications to Level 2 visualization and operation equipment

c) an open fieldbus communications to Level 0 equipment (if and where specified)

d) other process controllers (e.g. variable speed drives, electronic controllers, dedicated equipment control systems or other PLCs)

e) remote terminal units (RTUs), and telemetry systems

3.1.4 The hardwired I/O and network communication cards, together with the processor and power supply cards, shall all be housed in racks of one or more chassis units. Where chassis units are provided with spare slots for hardware expansion, these shall be protected by proprietary blanking plates. Any spare communications ports shall likewise be protected with dust covers or plugs.

3.1.5 The processor memory shall be sufficient to operate the as-installed programme with 20 % spare capacity, and the installed I/O cards shall be sufficient to operate the as-installed programme plus 10 % spare capacity of each I/O type used.

3.1.6 Once the program has been entered into the processor memory, it shall remain resident and unaltered, including under power down conditions, until it is deliberately modified by use of a programming unit. The processor shall contain a readily replaceable memory backup battery and indication of battery status.

3.1.7 The PLC / PCS shall be programmable using a standard portable notebook computer with suitable software as its programming device. The PLC / PCS shall be provided with all interfacing hardware and software; ready loaded and configured, to permit full access to the programme (including re-programming) via the standard serial communications port of a PC.

3.1.8 The processor shall incorporate the following indications as a minimum:

a) running

b) processor watchdog healthy

c) and I/O manipulation status

3.1.9 The processor watchdog signal shall be configured to raise an alarm upon CPU failure which shall be displayed on the associated HMI / SCADA or telemetry (where applicable).

3.1.10 The PLC / PCS CPU shall allow programme changes “on the fly”. In other words, minor changes to the control logic shall not require the CPU to be reset thereby causing the plant or works to be shut-down.

3.1.11 The PLC range shall offer various CPU memory, capacity, speed and I/O count sizes to suit the plant or works including “hot-standby”/ redundant CPU possibilities all as called for in the Project Specification.

3.2 PLC I/O

3.2.1 I/O cards shall be provided with voltages and signal loop currents (or voltages) as called for the in the Project Specification.

3.2.2 The I/O cards shall be keyed or otherwise configured to prevent maloperation if placed in the wrong position in a PLC / PCS rack, and each I/O card shall be capable of being individually removed or replaced without disturbing the wiring to adjacent cards.

3.2.3 Each I/O card shall be provided with an individually fused power supply feed, and an I/O card malfunction or power supply failure shall be recognised by the PLC hardware and software and raise an alarm on the CPU, relevant HMI or SCADA.

3.2.4 Conventional PLC I/O cards shall be limited to a maximum of 16 channels per card, and each I/O point shall be provided with an I/O status indicator. The use of 32 channel digital input cards will be subject to the card’s cable termination concept and approval of the Engineer.

3.2.5 The I/O wiring shall be segregated between input and output cards, and all I/O (including spare I/O) shall be loomed from the PLC card down to knife-edge (‘swinging blade’) disconnect type marshalling terminals from where these shall be marshalled to the field wiring. Where available, proprietary “looms” (connector / termination assemblies) shall be used to connect between the I/O card and the marshalling section.

3.2.6 Where it is necessary to maximise plant availability; e.g. with a duty / standby plant configuration, and more than one input card is available, the duty plant inputs shall be assigned to a separate card from the standby plant inputs. The same shall apply to the assignment of outputs to the plant.

3.2.7 Where mission critical applications require redundant IO these shall be accommodated by the choice of the PLC and appropriate CPU, and the circuitry shall be equally segregated as described above.

3.3 PLC Remote I/O

3.3.1 Where Remote I/O is called for in the Project Specification the I/O cards shall preferable be of the same type and range as those offered for the main PLC with centralised I/O.

3.3.2 Data communications from the PLC / PCS to Remote I/O shall be via a dedicated data communications medium and protocol specifically design for Remote I/O and the Data Communications medium from the PLC to HMI, SCADA or Field instrumentation may not be used for this purpose.

3.4 PLC I/O circuits

3.4.1 Digital input circuits, whether hard-wired to conventional I/O or connected via remote I/O, shall consist of volt-free contacts from control circuit components, equipment, and plant devices. These circuits shall be energised from the PLC end, and shall be “fail safe” in design, i.e. contacts shall open on PLC failure or alarm conditions and normal plant status conditions shall provide normally open contacts.

3.4.2 Digital outputs shall be provided with integral changeover relay contact suitably rated for the required switching duty, and shall be provided with suppression devices when switching DC loads. Alternatively, transistor output cards may be used in which case suitably rated interposing relays shall be included for each digital output in the Assembly.

3.4.3 Analogue input and output cards be capable of a minimum analogue to digital conversion resolution of 12 bits and shall include open circuit and short circuit monitoring.

3.4.4 Analogue inputs shall be powered either from the field instrument they connect to (where the instrument is separately powered with 230 V AC or 24 V DC), OR from a fused 24 V DC power supply at the PLC side where the instrument is loop powered. Each instrument loop circuit shall be designed for a loop impedance not exceeding 250 ohms.

3.4.5 Analogue outputs shall be powered from a fused 24 V DC supply via the analogue output card, and shall be able to drive into an impedance of up to 750 ohms. Analogue outputs shall provide a direct connection to the load (i.e. the whole primary loop).

3.4.6 Digital Inputs and Outputs shall be galvanically isolated in groups on no more than eight.

3.4.7 Analog Inputs and Outputs shall be individually galvanically isolated.

4. PLC SOFTWARE

4.1 General

4.1.1 PLC application software shall be written to meet the requirements of the plant or works Control Philosophy and the PLC processor shall be capable of being programmed using ladder logic, control system flow chart or statement list in accordance with SANS 61131-3. The software shall be laid out in a modular manner and structured in program and function blocks, such that similar tasks are of a similar structure and functionality to facilitate efficiency and ease of programming and maintenance.

4.1.2 Standard software Function Blocks shall be built up using the Client's standard suite of function (when available), or the PLC manufacturer's recommended standard Function Blocks.

4.1.3 Each line of code shall be fully documented and annotated, using mnemonics directly related to the associated item of plant. Function blocks shall be provided with descriptors e.g. analogue handling block, PID block, motor start block, etc. All data areas used shall be documented and a full memory map provided.

4.1.4 The PLC application software and operating data shall be held in appropriate memory locations; secured against power failure, and shall be provided with the facility for password protection against unauthorised access.

4.1.5 A sudden interruption of the power supply to the PLC shall result in the programme failing to a safe condition, and the PLC system shall not require manual attendance following a supply failure or restoration. The software control routines shall provide safe power-on and power-off sequences to ensure that the process is in a safe and controlled condition at all times.

4.1.6 Where a PLC forms part of a networked plant control system, it shall have a standalone operating capability such that in the event of a network failure it shall be able to continue monitoring and controlling its associated plant; using any set-points and parameters available prior to any network failure, including the ability for operators to change duties, monitor alarms, etc. via any associated local operator interface such as an HMI as called for in the Project Specification.

4.1.7 All software necessary to programme, operate, or maintain any equipment or component within the Assembly, including any network connectivity software, shall be provided, and shall be licensed in the Client's name.

4.2 PLC software structure

The PLC application software controlling the plant shall be structured so as to provide, as a minimum requirement, the software routines for each key functional area as detailed in the following clauses:

4.2.1 Plant initiation

This key functional area shall contain routines developed to control plant start-up and restart, plant reset, and phased plant starting, after a power supply re-energisation; including a return to the control mode selected prior to powering down. Plant trips, when reset by the operator, shall reinstate normal automatic operation without the need for further operator intervention.

4.2.2 Plant automatic control

This key functional area shall contain all software necessary to provide automatic control of the plant process(es) and shall include alarm generation and exception handling, together with the starting-up and scheduling of any associated standby plant.

4.2.3 Plant shutdown

This key functional area shall contain routines developed to control plant shutdown, including under operational, power failure, and unplanned / emergency conditions.

4.2.4 Operator and remote interface(s)

This key functional area shall contain all software necessary to provide interfaces to the local HMI, and to SCADA or telemetry (where required). All digital points to / from the HMI, to / from the SCADA system, or to the telemetry system, shall be held within separate integer registers or memory areas, and all analogue points to / from the HMI, to / from the SCADA system, or to the telemetry system, shall be held within separate floating point registers or memory areas.

4.2.5 Interlocks

The PLC / PCS programming shall provide for two types of interlocks namely process and safety interlocks.

a) Process Interlocks:

   i) These are dictated by the physical flow of material through the plant and are typically programmed between motor, valve, actuator and controller software blocks.

   ii) Equipment being prevented from start-up by a process interlock shall clearly indicate this condition on the SCADA system.

b) Safety Interlocks:

   i) These are typically hardwired into the motor, valve or actuators control circuit, latched and reset in the MCC whilst monitored by the PLC and shall indicate as faults on the HMI or SCADA system.

4.3 PLC software control routines

4.3.1 The development of the PLC application software shall include as a minimum, the routines detailed in the following clauses.

4.3.2 For all plant items, the selection of automatic control via the auto-available input signal shall be recognised by the PLC and displayed at the associated HMI, SCADA (and where appropriate, at a remote telemetry SCADA terminal). When an item of plant is selected for hand control, facilities for the rescheduling of any standby plant shall be provided.

4.3.3 Direct operator control via the PLC of each plant item (where that plant item is selected for automatic control) shall be provided from the associated HMI (and where appropriate, at a remote SCADA terminal). The selection of direct control shall leave the plant item state unchanged until a new control command is issued, at which time the rescheduling of any standby plant item shall take place.

4.3.4 Where duty / standby (or assist) plant is provided, the software control regime shall provide scheduling of these plant items through rotation of the duty / standby (or assist) functions. The duty rotation shall be dependent either upon the hours run for that item of plant selected for duty, or upon the issue of a manual duty rotate command. The required duty hours (between zero and 999) shall be entered by the operator at the associated HMI (or where appropriate, at a remote SCADA terminal). An entered value of zero duty hours shall inhibit the duty function within the associated plant item's duty rotation cycle. For those areas of plant where an apportioned wear pattern is required, an operator warning message shall be issued if the duty cycle hours entered for each item does not provide an uneven wear pattern. Where the operation of plant items is determined by upper and lower process limits, the automatic changeover of duty status shall be delayed until an appropriate point within the operating cycle.

4.4 PLC monitoring software

4.4.1 Monitoring software shall be provided to confirm the running of plant items in response to any start command, and shall use separately configurable time delays for each item of plant. If an item of plant fails to start within its configured time, the item of plant shall be deemed to have failed and an alarm shall be generated. The monitoring software shall also provide the accumulated run hours for all motor driven and proprietary items of plant.

4.4.2 When an item of plant fails, the control system shall automatically reschedule any standby plant item in place of the duty plant, and execute the appropriate shut-down sequence for the failed plant item. The standby plant item shall continue to operate in place of the failed duty plant item, until the plant item failure condition has been reset by the operator. Once the plant item failure condition has been cleared by the operator, the restored duty plant item shall operate and the standby plant item shall return to its standby status.

4.4.3 Monitoring software shall be provided to confirm the position of all valve(s) and penstock(s) in response to any open or close request, and shall use separately configurable time delays for each valve or penstock. If a valve or penstock fails to achieve the requested position, within its configured time, the valve or penstock shall be deemed to have failed and an alarm shall be generated.

4.4.4 Monitoring software shall be provided for the associated HMI, SCADA (and where appropriate, at a remote telemetry SCADA terminal), to generate operator message prompts where there is a need to manually exercise control over items of plant which remain in a static operating position or dormant state for extended periods of time. Where applicable, such plant will be identified in the Project Specification and / or Control Philosophy.

4.4.5 The PLC application software shall check all analogue input signals for validity. An analogue input signal shall be converted to a digital value at the I/O card, i.e. the current loop signal shall be converted to 0 - 4095 bits. The PLC software shall periodically check for a conversion which indicates under-range or over-range. If either of these two states is set, the software shall initiate an 'out of range' alarm.

4.4.6 In order to prevent the operator being presented with excessive spurious alarm messages, the PLC application software shall include routines, that on the initiation of a specific event alarm, shall prevent cascade alarms from being raised i.e. a 'mains failure' alarm will mask the 'not available' alarms from individual motor starters, valves, etc.

4.4.7 The PLC application software shall generate totalized quantities for individual items of equipment and instrumentation, whereby a pulsed digital signal shall be received and a set amount added to a totalizer register. The set amount used to increment the totalizer shall be adjustable and stored in a register. The totalizer shall be capable of the range 0 to 999999, and the totalizer shall automatically rolling over to zero when the maximum figure has been reached. The totalizer figures shall be displayed on the associated HMI display, SCADA (and where appropriate, at a remote telemetry SCADA terminal).

4.5 Functional Specification

4.5.1 Prior to programming the PLC or PCS, the Contractor shall provide the Engineer with a Control System Functional Design Specification describing how the Plant or Works Control Philosophy will be implemented in the Control System Software (PLC/ PCS).

4.5.2 The Functional Specification shall include at least the following:

a) Control System Overview

b) Final Approved plant or works Control Philosophy

c) Equipment, Motor and Instrumentation Lists

d) PLC IO lists

e) List of Interlock signals

f) List of Alarms

g) List of all PID control Loops

h) List of all Sequence and / or Duty/ Standby control

i) Detail description of PLC configuration and software building blocks (Function Blocks)

j) Function Block Parameters tables

4.5.3 The Functional Specification shall be issued to the Engineer for approval.

4.5.4 On completion of the contract the Functional Specification shall be converted into a Control System Functional Description and incorporated into the Operations and Maintenance Manuals.

5. INSTALLATION REQUIREMENTS

5.1.1 The PLC / PCS shall be installed in a dedicated enclosure conforming to the Engineering Standard SPE-II-0001 “General Electronic Installations”.

5.1.2 A separate Assembly shall be provided for each plant or works control area as called for in the Project Specification.

5.1.3 Each Assembly shall be physically located in the plant or works electrical load center(s) together with the associated Low Voltage Motor Control Center(s) (MCCs) OR in a dedicated centralized control room with remote IO at the MCC; all as called for in the Project Specification.

5.1.4 The installation, termination, earthing and lightning/ surge protection of the PLC/ PCS enclosure (and all associated components) shall conform to the requirements of the Engineering Standard SPE-II-0001 “General Electronic Installations”.

6. TESTING AND COMMISSIONING

The Controller Assembly(ies) shall be tested and commissioned as described in the Engineering Standard SPE-II-0001 "General Electronic Installations" with specific attention to the following:

a) During development, software shall be electronically verified apart from the process it controls using a simulation / diagnostic package.

b) The control systems shall be tested with the software loaded into the programmable devices, and with simulation of the physical I/O devices to equipment such as MCCs and Field Instrumentation and the Operator interface HMI and / or SCADA.

7. DOCUMENTATION AND TRAINING

Comprehensive documentation, training and operations & maintenance manuals shall be provided for each PLC / PCS Assembly provided for the plant or works under this contract, all as described in the Engineering Specification SPE-II-0001 “General Electronic Installations”.

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Radio Telemetry

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Contents

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1. SCOPE

1.1 Application

1.1.1 This Specification covers the requirements for a radio telemetry system. The primary intention of this Specification is to ensure the delivery of a Radio Telemetry system which has been properly designed and constructed to ensure safe reliable operation and is simple to maintain.

1.2 Telemetry system

1.2.1 Design, supply, delivery, installation, testing and commissioning of the necessary hardware and software constituting a complete and fully operational Telemetry system.

1.2.2 A typical telemetry system covered by this specification shall consist of the following;

a) Master or Base Station

b) Remote Slave or Outstations

c) Radio Frequency (RF) equipment

d) Antenna and Mast(s)

e) Remote Terminating Unit(s) (RTU's)

f) Power Supply equipment

g) Power supply, signal and RF cabling

h) Equipment Earthing

1.2.3 The exact system configuration and related equipment necessary for the complete installation, shall be as detailed in the Project Specification.

1.3 General

1.3.1 The following definitions are used in this Specification:

a) The term "Telemetry Station" shall apply to both Base Stations and Outstations.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification identifies the Employer's standard modifications and requirements, which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Project Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Standard Engineering Specification.

2.1.2 The design, construction, installation, inspection, testing and commissioning of the Installation shall comply with all relevant Statutory Regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.

2.1.3 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.

2.2 Regulations, Specifications and Standards

2.2.1 The design, construction, inspection and testing of the Telemetry system shall comply with all relevant Statutory Regulations and Directives including:

a) The Telecommunications Act, 2000

b) The Independent Communications Authority of South Africa Act, 2000

c) Electronic Communications Act, 2005

d) Occupational Health and Safety Act (Act 85 of 1993);

e) Construction Regulations 2003 issued in terms of Section 43 of the Act;

f) Local Fire Regulations; and

g) Regulations of the Local Supply Authority.

and the latest editions (current at the time of Tender) of all relevant SANS, British Standards and International Standards, including:

Table 1: Reference Standards

Standard Number	Description
SANS 1063	Earth rods, couplers and connections
SANS 1091	National colour standards of Paint
SANS 10142-1	Wiring of Premises, Part 1: Low Voltage Installations
SANS 10199	The design and installation of earth electrodes
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 61643	Low-Voltage Surge Protection Devices
NRS 042	Guide for the protection of electronic equipment against damaging transients

2.2.2 The installation shall also comply with:

a) This Specification including all Technical Data Sheets; and

b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

2.2.3 The Contractor shall follow an approved, auditable quality assurance procedure covering the design, construction, and inspection and testing of the Installation.

3. TELEMETRY SPECIFICATION

3.1 General

3.1.1 The Telemetry system shall be primarily intended as a long distance radio frequency communications medium to obtain data from remote locations and present them on a SCADA computer (or mimic control desk) for mainly monitoring, logging and trending purposes but in special cases also for control purposes.

3.1.2 In special cases, and only when directed by the Engineer or Client in the Project Specification, the Telemetry system may also be used as a communications medium between control devices such as Programmable Logic Controllers (PLC).

3.1.3 The Telemetry system shall be implemented as a distributed digital data communications network.

3.1.4 Each Telemetry station shall be supplied as a complete stand-alone self-contained unit suitable for floor standing or wall mounting providing an autonomous fully functional system.

3.1.5 The Telemetry system shall operate in the licenced UHF radio frequency band and/ or the licenced Microwave frequency band and only under special circumstances, and as directed by the Engineer or Client in the Particular Specification, shall the unlicensed frequency bands (e.g. Spread Spectrum Modulation) or Global System for Mobile Communications (GSM) technology be used.

3.1.6 All Telemetry equipment, including that to which it connects (e.g. PLCs or Computers) shall be adequately protected against the effects of Electromagnet Interference (EMI) and Radio Frequency Interference (RFI) as also described in the Engineering Specification SPE-II-0001 "General Electronic Installations".

3.1.7 The Contractor shall be responsible for ensuring electromagnetic compatibility of the control system components with one another and with the overall electrical and mechanical installation on the plant or the works.

3.1.8 Each Telemetry station shall include a battery backed up power supply for continued operation even under mains supply failure conditions.

3.1.9 The installation shall be earthed and include lightning protection measures for the Telemetry equipment and it's antenna supports/ masts as well as providing surge arrestors on the power supply, all signal and RF circuitry, all as detailed in the Engineering Specification SPE-II-0001 "General Electronic Installations".

3.2 Functional requirements

3.2.1 The prime purpose of the Telemetry system shall be to transfer data between outstations and a base station then on to a SCADA system according to one of the standard Telemetry protocols as stipulated in the Project Specification.

3.2.2 It shall be possible to fully and freely diagnose, programme, configure and test the Telemetry stations both locally and remotely by means of a data cable connected to a portable programmer/ computer or via the radio communication channel.

3.2.3 The Telemetry system shall allow voice communications over the radios between stations to assist with network commissioning and transmission troubleshooting.

3.2.4 All Telemetry data shall be transmitted in a digital format with a baud rate that is appropriate for the application.

3.2.5 The remainder of the Telemetry network shall not be affected by the failure of any one of the network's outstations.

3.3 Telemetry Remote Terminating Unit (RTUs) detailed requirements

3.3.1 General

a) The RTU shall be of robust design suitable for industrial application and shall have a proven industrial track record in the RSA.

b) The RTU shall monitor and control all points connected to the RTU as detailed in the Project Specification.

c) The design of the RTU shall be such that the minimum number of function cards are required to support binary input/outputs and analogue input/outputs.

d) All function cards shall be interchangeable between RTU's with the possibility to re-configure the card's address configuration, preferably through software.

e) The RTU's configuration settings shall be stored in non-volatile memory (NVRAM) thereby not requiring an external battery to support it during a power failure.

f) Programmable RTUs (i.e. with Logic Functionality) shall be provided when stipulated in the Project Specification and such RTUs shall be supplied with an internal battery, providing backup for a minimum of ninety (90) days of the programmed functionality.

g) The RTU(s) shall be suitable for installation in standard electrical enclosures, either separately floor standing, wall mounted or located within a separate compartment of the Low Voltage assembly it is associated with. The layout / general arrangement of the components and the overall enclosure size shall be submitted for the approval of the Engineer before manufacture and assembly.

3.3.2 Components

RTUs shall be modular and consist of the following components:

a) A central processing unit (CPU).

b) Communication interface(s) (either integral to the CPU or as separate modules).

c) Input and output modules (I/O Modules) suitable for analog, digital signals, and counter inputs.

d) A power supply unit.

e) A separately contained battery backed up power source consisting of a charger and low maintenance battery set to suit the system duty.

f) Screw Terminals and surge protection modules for signal and power circuits.

3.3.3 Enclosure

a) The RTU components shall be installed in a lockable enclosure constructed of materials as stipulated in the Project Specification and with internal mounting / chassis plate, external ON/OFF switch, system TEST button and external system ON pilot light.

b) The RTU Central Processing Unit (CPU), Power supply Unit (PSU) and I/O Modules shall be mounted on standard DIN-rail, or in 19 inch rack mount frames as stipulated in the Project Specification.

c) The means of connection between the modules and the back-plane for 19 inch rack mounted modules shall be submitted for the approval of the Engineer.

d) For DIN rail mounted modules the connection between CPU, UPS and I/O modules shall be by means of ribbon cable in "daisy chain" fashion using connectors with eject latches and strain relief.

e) Power supply (PSU) equipment that is neither 19 inch rack mountable or DIN rail mountable shall be securely fixed with brackets to the RTU enclosure chassis plate.

f) Input and Output connections to the I/O modules shall be by means of rail mounted screw terminations suitable for multi-stranded copper conductor wires with a cross sectional area of up to 1.5 mm². The I/O Module shall be able to be unplugged and removed without disturbing the field wiring.

g) All I/O modules shall be keyed to ensure that only the correct type of I/O Module can be plugged into a specific wired location. All connectors shall be D-type or similar to prevent the reverse connection of modules.

3.3.4 Central Processing Unit (CPU)

a) The CPU module shall be a completely self-contained microprocessor based unit specifically designed for RTU Telemetry communication system.

b) The CPU Module shall be equipped with a CPU watchdog timer circuit that will automatically restart the system in case of severe electrical disturbances. It will also check that the RTU program is regularly executed.

c) The CPU memory capacity and number of internal registers, inputs and outputs that the CPU can support shall be as detailed in the Project Specification.

d) The CPU Module shall be able to accommodate the following types of extension modules:

i) Digital inputs and outputs

ii) Analog input and outputs

iii) Pulsed Counter inputs.

e) The CPU shall be programmable with IEC61131 Logic as and when stipulated in the Project Specification.

3.3.5 Power Supply Unit (PSU)

a) The PSU module shall be an SABS, CE or UL approved regulated conditioning 24 V DC power supply unit that receives its power from either 230 V AC 50 Hz or 24 V DC battery supply system as described in the Project Specification.

b) The output voltage and power output of the unit shall be selected to suit the complete RTU installation and all associated peripherals. i.e. to power the CPU, IO Modules, communications modules and all Input and Output circuits plus 25 % spare capacity.

c) The unit shall comply with the minimum operating parameters and conditions as stated in the relevant Data Sheet.

d) PSU modules shall be either DIN rail mounted or supplied with fixing arrangements for chassis mounting.

3.3.6 Data communication

a) The RTU shall provide one or more serial communications port(s) with data bit rates of minimum 9,600 baud up to 152,000 baud.

b) The RTU shall be able to communicate with a SCADA system and/ or with other RTU's via a serial radio or modem using one of the industry standard data communications protocols as stipulated in the Project Specification.

c) Propriety protocols will not be accepted and the minimum protocols that shall be supported are:

i) Modbus RTU

ii) Distributed Network Protocol (DNP3)

iii) IEC60870-5-101

iv) MPT1327

v) Transport Control Protocol / Internet Protocol (TCP/IP)

d) The integrity of the data communicated over the telemetry system shall be ensured according to the chosen protocol. The probability of an error going undetected shall be less than 10-5 for a transmission rate of 9600 baud and a signal to noise ratio better than 10 dB.

e) The Telemetry System shall be able to acknowledge messages received on the radio link or modem and shall be capable of re-transmitting a message if it is not acknowledged after a pre-determined time-out period, all according to the chosen protocol. It shall be possible to select the protocol by means of software configuration or a DIP switch setting. A station shall attempt 3 re-tries at transmitting a message, if it is not acknowledged.

f) The system shall support time-stamping of all events at a remote station, and transmit this time-stamp data to the base station (e.g. Digital Change-of-State or Analog configurable percentage Change-of-Value).

g) Time-stamps shall be possible down to at least 1 ms resolution.

h) The Telemetry base station shall pass time-stamped event data to the SCADA for display, alarming and/ or logging purposes.

i) Provision shall be made at each station to prevent permanent radio transmission under fault conditions. Valid data transmissions shall be made according to the stipulated protocol.

3.3.7 Addressability

a) Each RTU shall be allocated a unique station address.

b) The system shall support a minimum of 256 RTU addresses (with Address 0 and 255 reserved for system use).

c) Each RTU shall be capable to handle a minimum of 2048 I/O's.

3.3.8 Modes of operation

All RTU's shall support three modes of operation corresponding with the applicable communications protocol, being:

a) Interrogation by Master (Polling)

i) The RTU’s CPU Module shall be configurable to define the station as fulfilling a Master or Slave role.

ii) A Master station shall interrogate (cyclically poll) all slave stations allocated to that specific Master. The Master shall initiate this interrogation sequence on a set time-interval and station address priority sequence as programmed.

iii) The polling sequence shall be executed as follows:

- The Master shall transmit its own control data so as to update all slave stations with corresponding Decode Channels.
- The Master shall then proceed to transmit a polling request command datagram to each slave station.

- Polling requests shall be typically 3 seconds apart (default value), allowing enough time for the Interrogated station to respond. Data exchange with the slave station shall be completed before proceeding to the following Station.
- The station that is polled shall respond within a defined time-out and number of retries, by transmitting all its I/O Module data as well as configuration data.
- The SCADA system shall send and receive data to and from the Master station after every polling cycle.

b) Change-of-State Mode

i) The Change-of-State Mode shall enable any slave station to transmit when any input data changes, e.g. a digital input changes state or an analog input changes by a configurable difference value.

ii) The RTU shall allow the user to be able to set individual change of value parameters for each of the analogue inputs and individual change of state 'debounce' timers for each of the digital inputs.

iii) Digital inputs shall be 'de-bounced' in software, requiring that a state exists for longer than a preset, but adjustable time (default value 300 ms) before it is regarded as a change-of-state.

c) Timer

i) The RTU's CPU shall be configurable (through software or hardware) to allow different Timer mode settings that enable the slave station to transmit its input data at regular time-intervals.

ii) The following time intervals shall be accommodated:

- timer off = timer mode disabled
- timer enabled to 1 minute
- timer enabled to 5 minutes
- timer enabled to 10 minutes
- timer enabled to 20 minutes
- timer enabled to 30 minutes

3.3.9 I/O modules

The following I/O modules, as detailed below shall be available:

a) Digital input modules

i) Digital input modules shall be able to accommodate potential free contacts and transistor inputs (NPN and PNP).

ii) All digital inputs shall be protected against accidental voltage inputs of up to 240 V AC.

iii) Digital input modules shall be able to accommodate 8, 16 or 32 inputs per module with a minimum grouping of 8 inputs with common ground per module.

b) Digital output modules

i) Digital output modules shall provide transistor or relay contacts as output.

ii) The relay contacts shall be rated for 24 V DC 5A or 220 V AC 6A and shall be capable of withstanding an inrush current of 15 A.

iii) Digital output modules shall be able to accommodate 4, 8 or 16 individual outputs per module.

c) Analog input modules

i) All analog inputs shall have a resolution of 0,1 %. All analog values shall be converted to at least a 12 bit digital signal for telemetry transmission.

ii) Analog input modules shall be able to accommodate 2, 4 or 8 analog inputs per module.

iii) All analog inputs shall be individually and galvanically isolated.

iv) The following types of analog inputs shall be accommodated and shall be field selectable:

- 0-5 V DC
- 0-10 V DC
- 0-20 mA and
- 4-20 mA

d) Analog output modules

i) All analog outputs shall have an accuracy of better than 0,1 % of full scale.

ii) Analog output modules shall be able to accommodate at least 2, 4 or 8 analog outputs per module.

iii) All analog output modules shall be individually and galvanically isolated.

iv) The following types of analog inputs shall be available and shall be field selectable:

- 0-5 V DC
- 0-10 V DC
- 0-20 mA and
- 4-20 mA

e) Counter input modules

i) Counter inputs shall be suitable for accumulating up to 65 536 pulses (16 bits) at the outstation, at a rate of up to 10 pulses per second.

ii) Counter inputs shall be suitable for potential free contacts.

iii) Counter input modules shall be able to accommodate at least 4 counter inputs per module.

3.4 Communication system

3.4.1 The Telemetry system shall primarily make use of a Digital Radio Carrier Frequency communications device to transmit and receive data between the base station (master) RTU and out station (slave) RTUs. Alternate communication means shall be via fibre optic or leased line (telephone) media using suitable converters and modulator / demodulators (MODEM).

3.4.2 Only Radio Carrier equipment that is approved and licensed by the Independent Communications Authority of South Africa (ICASA) for use in the Republic of South Africa will be accepted.

3.4.3 Radio transceivers shall preferably be fully synthesized and programmed only for those frequencies granted by ICASA for use in the project area.

3.4.4 The Radio transceivers shall be capable of both data and regular voice channels (The voice channel shall be accessible during commissioning and fault finding).

3.4.5 Radio equipment shall include repeater functionality where communications paths cannot be achieved directly. Radio signal repeating shall be provided by either linking two radios and using adjacent frequencies (more than 12.5 kHz separation) or by digital store-and-forward methods using the same frequency.

3.4.6 Radio and Frequency selection shall be application specific and as detailed in the Particular Specification. In general the following frequencies and Radios shall be required;

a) Digital Radios using Frequency Shift Keying (FSK) operating in an allocated frequency of the UHF spectrum range (400-450 MHz)

b) Digital Trunked Radios using Time Division Multiplexing (TDMA) operating in an allocated frequency of the UHF spectrum range (380-400 MHz)

c) General System for Mobile Radio (GSM/GPRS) in the UHF range (900 MHz) operating under a public “cellular” service provider account.

d) Spread Spectrum Radios using IEEE802.11 standards operating in the 2.4 GHz, 3.5 GHz or 5 GHz “microwave” range under general unlicensed multi access wireless Ethernet principals.

3.4.7 Each telemetry station (Radio and RTU) shall provide communication ports supporting physical link layer connectivity via RS-232/RS-422/RS-485/USB or Ethernet standards, and communications protocols such as Modbus-RTU, DNP-3, IEC60870-5-101, MPT1327 (Trunked Radio), GSM/GPRS (Packed Radio) and TCP/IP (Spread Spectrum Radio) for:

a) Communication link to master site (e.g. by modem)

b) Interface to diagnostics terminal

c) Interface to SCADA operator station

d) Interface with PLC’s.

3.5 Antennae and Masts

3.5.1 Antennae and mast selection shall be done based on a radio propagation study taking into account the topographical data in the area and the required signal strengths for reliable and error free transmissions.

3.5.2 The type of antennae selected shall be suitable for the radio communications medium chosen and as specified in the Project Specification i.e. typically for UHF, GSM and Trunked radio this shall be a dipole whip type or collinear antennae or Yagi-uda type and for Microwave radio it shall be a parabolic dish.

3.5.3 The complete structure of antennae and masts for base stations, out stations and repeater stations shall be capable of withstanding steady state or gusting wind velocities up to 160 km/h at 10 m above ground level.

3.5.4 Where masts and antennae are erected in areas with expected temperatures below zero resulting in icing (or snow build-up), they shall additionally be capable of carrying a coating of ice of up to 12 mm thick.

3.5.5 Masts exceeding 8 m in height shall be either of tubular or lattice construction.

3.5.6 All masts sections shall be galvanised in accordance with SABS 763-1977. No drilling, cutting or welding shall be permitted after galvanising. All bolts, washers, nuts, thimbles, turn buckles and similar small parts shall be hot-dipped or otherwise electro- galvanised after machining is completed.

3.5.7 Where riveted mast sections are offered, the riveting shall be carried out at the manufacturer's works employing heated high tensile steel rivets. Cold riveting on site shall not be acceptable.

3.5.8 Tubular mast designs shall employ joints between sections, of the flanged, parallel sleeve socketed or taper sleeve socketed type. Screwed socketed types shall not be permitted. Only bolts and nuts shall be used for construction on site.

3.5.9 Where masts require rigging to install, these shall be by wire ropes and such ropes shall be terminated using appropriate thimbles. Pressure weld splicing is preferred to the use of Crosby clamps or handmade splices.

3.5.10 Where guy wires are attached to lattice masts, the guy wires shall not pull on the mast legs, but shall be attached to a guy tie frame.

3.5.11 In the case of out and base station masts with a total height of less than 9 m, it will be preferable for the supplier to offer masts which can be erected and unrigged by the use of an erection mechanism. This type of mast shall be so designed that maintenance staff can lower them at will and re-erect them without requiring special cranes and/or rigging equipment.

3.5.12 For fixed masts, a safety-climbing means/ device shall be supplied to enable maintenance of the masts and antennae to be carried out. If a caged ladder on the mast is to be used for maintenance purposes, it shall comply with the Occupational Health and Safety Act of 1993. The manufacturer shall supply detachable steps for the first 3 m of masts above ground level.

3.5.13 When directional antennae have to be mounted on the masts, the brackets and mounting hardware to be used shall allow redirection of the antennae without damaging painted and galvanised mast sections.

3.5.14 Painting (when required a stated in the Project Specification) shall ensure that all mast sections and members are protected by an appropriate number of layers of the specified high quality paint. The coating shall be applied in such a way that no bare metal is exposed on any part of the mast, mast base or guy wires and mounting accessories.

3.5.15 Before painting any piece of metal, the surface shall be properly treated with the necessary reagents, solvents, etching primers and the like to ensure long-lasting protection of the metal surface by the paint.

3.5.16 Galvanised mast members shall be treated in accordance with the requirements of SABS method 26 (as far as practically possible) or an equivalent method before any paint is applied to the metal surface.

3.5.17 In the case of non-galvanised mast sections, paintings shall be done according to the SABS 046-1979 specifications.

3.5.18 No section of any mast which is to be set in concrete (i.e. mast base section, holding down bolts, bolt frame, etc.) shall be galvanised. These sections shall be untreated mild steel, all protruding surfaces shall be thoroughly cleaned and painted with bitumen epoxy as per SABS 1200 HC after the footing has cured.

3.5.19 The antennae cable shall be installed either inside the mast (accessible from removable covers) or in a 20 mm HDG Conduit with end caps attached to the mast via bolted saddles.

3.5.20 In general masts taller than 30 m shall be equipped with aircraft warning lights with the amount and placement of lights in accordance with CAA recommendations as stipulated in the Project Specification.

3.6 Power Supply

3.6.1 General

a) The complete Telemetry equipment shall be supplied with electrical power from either a low voltage mains supply source when available or a stand-alone generator power supply where mains supply is not available.

b) The arrangement shall furthermore include battery back-up in all cases such that the Telemetry station remains operational for a prescribed amount of time in the event of a power outage as stipulated in the project Specifications.

3.6.2 Mains power supply

a) Mains power supply shall be at low voltage, 230 V AC, 50 Hz single phase via a Circuit Breaker suitably sized to isolate the supply and protect the equipment against overload and/ or short circuit.

3.6.3 Battery supply

a) Battery supply shall be at 12 V DC or 24 V DC with a suitable quantity and configuration chosen to suit the back-up time required with the calculated static load of all Telemetry related equipment. A fully operational back-up time of 24 hours is required unless otherwise specified.

b) Batteries shall be of the low maintenance or maintenance free types using Lead Calcium or Metal Halide cells.

3.6.4 Chargers

a) Battery chargers shall be designed to maximise battery life and effective battery capacity. Preference will be given to intelligent battery management type chargers. Chargers shall not permit the batteries to be overcharged or over depleted

b) The charger shall be rated to completely recharge the battery within 12 hours for a fully discharged battery at 25 ºC while delivering the static load.

c) Photo Voltaic solar panels with associated battery chargers shall be provided at outstations and repeater stations when stipulated in the Project Specification. The capacity of these chargers shall be sufficient to allow operation of the system to continue under 80 % overcast conditions lasting for periods up to two weeks. Allowance shall also be made for the fact that dust and dirt may settle on the solar panels. Solar calculations shall be supplied by the Contractor for approval by the Engineer.

d) Solar panels shall be of the Photovoltaic multi-cell type and be fitted with a protective cover material that shall be installed in a frame of hot dipped galvanized angle iron at least 3 mm thick. The frames shall make it difficult to remove the panels without special tools or shall be lockable.

e) Solar panels shall be provided with a switch to detect its removal and this signal shall be relayed to the outstation inputs for transmission as an alarm.

f) When called for in the Project Specification, Wind chargers shall also be required. A horizontal variable wind turbine type charger shall be provided and sized to suit the installation.

g) Wind turbine chargers shall be supplied complete with mounting mast and shall be mounted so that there is no interference with the radio mast. The blades of the propeller shall have at least a 2,5 m ground clearance. The blades shall automatically furl in high winds (>16 m/s) to govern the speed.

h) Wind turbines shall be equipped with maintenance free sealed bearings. If the charger is mounted in areas with expected sub-zero temperatures, the bearing lubrication shall be chosen to operate below freezing point.

i) The charger output shall match the batteries and shall be either 12 V DC or 2 4 V DC. In light winds (4 – 8m/s), the charger shall still be capable of delivering a minimum of 10 % of rated output.

3.7 Maintenance Facilities

The telemetry system shall provide facilities to enable non-qualified personnel to be able to assess the proper operation of a station.

3.7.1 Indications

The status (program running/failed and communications OK/failed) of each I/O module and channel shall be indicated by visible status LED's.

3.7.2 Test transmissions

A selector switch shall be provided to enable a Test Transmission to be sent and received from a selected outstation to assess the quality of communications.

3.7.3 Serial port

A serial port shall allow a maintenance PC (e.g. Laptop) to monitor the communication system of any outstation.

4. INSTALLATION REQUIREMENTS

4.1 General

4.1.1 The Telemetry equipment shall be installed in a dedicated enclosure conforming to the Engineering Specification SPE-II-0001 “General Electronic Installations”.

4.1.2 A separate enclosure shall be provided for each Telemetry station related to a reservoir, pump station or treatment works as called for in the Project Specification.

4.1.3 The installation, termination, earthing and lightning/ surge protection of the Telemetry enclosure (and all associated components) shall conform to the requirements of the Engineering Specification SPE-II-0001"General Electronic Installations" with additional requirements stipulated below.

4.2 Telemetry Antennae and Masts Air Terminal

4.2.1 A vertical steel or copper clad steel rod or tube lightning conductor, of minimum diameter 15 mm) shall extend above the top of all masts so as to provide a 30 degree cone of protection (measured to the vertical). The rod shall be bonded to the mast by welding or brazing except where otherwise indicated in the Project Specification.

4.2.2 A copper bonding conductor of 70 mm² cross sectional area bare stranded copper shall be run from the top of the mast downwards. This conductor shall be bonded to the mast at several points, with the interval between adjacent bonds not exceeding 1,5 m. All metallic elements in the vicinity of down conductors should be bonded to the conductor. The top bond to the down conductor shall be to the air terminal on top of the mast. The bonding shall be done by welding or brazing process in the case of non-galvanized sections and by the use of clamps in the case of galvanized sections. The bottom end of the down conductor shall be bonded to the earth point.

4.3 Antennae

4.3.1 At least one point on each antenna shall be directly connected to the protective earth. Antennae shall be mounted to the masts with suitable clamps and no metal or plastic straps shall be used for this purpose.

5. TESTING AND COMMISIONING

5.1.1 The Telemetry system shall be fully tested and commissioned as described in the Engineering Specification SPE-II-0001 "General Electronic Installations" with specific attention to the following:

a) The Radio frequency, transmission strength and received signal intensity shall be tested, measured and recorded in order to ensure reliable and error free transmission. A copy of all tests and measurements shall be submitted to the Engineer for approval and shall be bound into the Operations and Maintenance manuals.

b) The RTUs shall be tested with their configurations (and software if programmable units have been specified) loaded into the devices and connected to the actual devices, by simulation of the physical I/O devices to equipment such as MCCs and Field Instrumentation and the Operator interface HMI and / or SCADA.

6. DOCUMENTATION AND TRAINING

6.1.1 Comprehensive documentation, training and operations & maintenance manuals shall be provided for each Telemetry station provided for the reservoir, pump station and/ or treatment works under this contract; all as described in the Engineering Specification SPE-II-0001 “General Electronic Installations”.

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Engineering Standard

Supervisory Control and Data Acquisition

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1. SCOPE

1.1 Application

1.1.1 This Specification covers the requirements for a Supervisory Control and Data Acquisition (SCADA) system.

1.1.2 The primary intention of this Specification is to ensure the delivery of a SCADA system which has been properly designed and constructed to ensure safe, reliable operation and is simple to maintain.

1.1.3 The scope of work shall encompass the following:

SCADA system: Design, supply, programming, delivery, installation, testing and commissioning of the required computer hardware, software and peripheral's constituting a complete and fully operational SCADA system including, but not limited to, the system functions as specified herein.

1.1.4 The exact system configuration and related equipment necessary for the complete installation, shall be as detailed in the Project Specification.

1.2 General

1.2.1 The following definitions are used in this Specification:

The term "SCADA" shall include the complete Supervisory Control and Data Acquisition system comprising of server computers, client workstation computers, database servers, engineering computers and all peripherals such as network switches, cabling, printers and power supplies.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Project Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Standard Specification.

2.1.2 The design, construction, installation, inspection, testing and commissioning of the Installation shall comply with all relevant Statutory Regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.

2.1.3 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.

2.2 Regulations, Specifications and Standards

2.2.1 The design, construction, inspection and testing of the SCADA and telemetry system shall comply with all relevant Statutory Regulations and Directives including:

a) Occupational Health and Safety Act (Act 85 of 1993);

b) Construction Regulations 2003 issued in terms of Section 43 of the Act;

c) Local Fire Regulations; and

d) Regulations of the Local Supply Authority.

and the latest editions (current at the time of Tender) of all relevant SANS, British Standards and International Standards, including:

Table 1: Reference Standards

Standard Number	Description
SANS 1063	Earth rods, couplers and connections
SANS 1091	National colour standards of Paint
SANS 10142-1	Wiring of Premises Part 1 : Low Voltage Installations
SANS 10199	The design and installation of earth electrodes
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 61643	Low-Voltage Surge Protection Devices
NRS 042	Guide for the protection of electronic equipment against damaging transients
Other	**Description**
ISA 5.5	Graphic Symbols for Process Displays
ISA 5.06	Functional Requirements Documentation for Control Systems
ISA 18.2	Management of Alarm Systems for the Process Industries

2.2.2 The installation shall also comply with:

a) This Specification including all Technical Data Sheets; and

b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

2.2.3 The Contractor shall follow an approved, auditable quality assurance procedure covering the design, construction, and inspection and testing of the Installation.

3. SCADA

3.1 General

3.1.1 System Overview

a) The SCADA system shall form an integral part of the plant / works' automation system.

b) The system shall provide the Human Machine Interface (HMI) between the operator and the plant / works, providing for overall supervision, co-ordination, control (dynamic process adjustments), operations monitoring and recording.

c) The SCADA system shall be connected to and collect data from field devices (e.g. RTU's, PLC's and Process Instrumentation) and record these in a relational database.

d) The SCADA system shall communicate (via appropriate protocol drivers) with field devices using data transmission methods and equipment as specified in the Project Specification and Technical Data Sheets.

e) The data obtained and recorded by the SCADA system shall be available via a SCADA local or wide area network (LAN/WAN) to any local (or remote) computer SCADA workstations for visualization, trending and analysis purposes.

3.1.2 Functional Requirements

The SCADA system shall communicate cyclically with its field devices at all times and shall perform, but not be limited to, all functionality in this specification. The main functions of the SCADA shall be:

a) Process related data and measurement acquisition

This feature shall include the following basic functionality:

i) Process variables and measurement data collection and storage to a Relational Database Management System (RDBMS) according to predefined logging intervals.

ii) Discreet signal processing, for example Status messages (on/off), open/close, etc.), alarm and event disturbance logging.

iii) Analogue value supervision, e.g. Range supervision, min/max value supervision, calculations and conversion from engineering to real values for Monitoring SCADA Radio Telemetry systems only (RTUs). NOTE: Analogue value supervision, e.g. Range supervision, min/max value supervision, calculations etc. for process control SCADA shall be done in the PLC and NOT the SCADA.

b) Report generation

The SCADA reporting feature shall provide the following functionality, in the form of a screen display, downloadable file, as well as printable hard copy:

i) Daily reports

ii) Monthly reports

iii) Yearly reports

iv) Alarm and disturbance reports

v) Operator Messages and Alerts

vi) Maintenance reports

vii) On demand data query reports

c) Process visualisation

The process visualisation feature shall provide the following functionality:

i) Dynamic process symbols (images / mimics)

ii) Display of trend curves from historical data

iii) Display of trend curves on a real time basis

iv) Display of operator alerts, messages, alarms and events

d) Operator command interface

Process control commands, setpoints and parameter changes shall be allowed by the operator via SCADA faceplates and shall include:

i) Control system set points.

ii) Switching drives on/off, opening/closing of valves, etc.

iii) Acknowledgement of error and alarm messages

e) Operator Access Security

The system shall provide for an access authorisation (password) system, whereby different level of operators shall be granted different operational authorisation as detailed further below and stipulated in the Project Specification.

3.1.3 General Requirements

a) All operator commands and settings as well as process measured values and status data that is communicated to and from the remotely connected devices shall be represented by a unique “tag” or “point” within the SCADA system.

b) All process measurements shall be done on-line, such that the SCADA system can respond to changes in the plant or works in real time.

c) The SCADA system shall be capable of operating in a stand-alone or client-server configuration with the capability of having multiple users and multiple workstations working simultaneously on a common SCADA implementation.

d) All equipment (hardware and software) shall have a proven track record and shall have a large user and technical support base.

e) Where computer hardware is specified, it remains the Contractors' responsibility to ensure that the actual hardware offered and installed is adequate to support the offered SCADA software and the specified SCADA functionality, including future expandability.

f) All computer hardware shall be suitable for industrial use and shall have been either purposely designed for industrial use or shall have been thoroughly ruggedised for use in an industrial environment.

g) Computing devices shall be certified to comply with the applicable regulations for Electromagnetic compatibility of electronic and digital equipment in order to limit harmful interference (such as to and from radio equipment).

h) The operational state of the SCADA system shall NOT detrimentally affect the automation and control of the plant or works. i.e. If the SCADA system fails or needs to be restarted, the PLCs, RTU's and Process Instrumentation shall continue operating the plant or works.

i) The complete SCADA system shall restart automatically when normal (or standby) power has been lost then restored (or re-activated).

j) All measured values and status data from the PLCs, RTUs and Process Instrumentation shall be buffered, retrieved and updated on the SCADA after an outage.

k) The SCADA system shall record the down time and in the event that data acquisition has failed and/ or failed to update missing data, shall flag the event and log the "downtime".

3.2 SCADA System Hardware

3.2.1 General

a) The hardware specified in the Project Specification and Technical Data Sheets shall include all necessary components for a fully functional SCADA installation, whether specifically listed or not.

b) All hardware shall be rated for continuous operation under the environmental conditions stipulated in the Project Specification.

3.2.2 Computer equipment

a) The computer hardware form shall be as stipulated in the Project Specification, with server computers typically prepared for computer cabinet rack mount and client workstation as well as engineering computers typically prepared for desktop installation. All computer equipment shall be from a reputable, branded supplier.

b) Computer equipment shall carry a minimum of a 2-year warranty.

c) The computer housings shall be robust and capable of operating in either controlled environments or industrial environments, as stipulated in the Project Specification.

3.2.3 Computer monitors

a) The size and number of monitors shall be optimised to allow the operator(s) to have a detailed overview of the full plant or works at all times.

b) Server monitors shall be backlit LED LCD type at least 19 inch, 4:3 aspect ratio and a minimum 1024x768 resolution or as stipulated in the relevant Data Sheet.

c) Workstation and engineering station monitors shall be the backlit LED LCD type and at least 23 inch, 16:9 wide aspect ratio and a minimum of 1920 x 1080 resolution or as stipulated in the relevant Data Sheet.

3.2.4 Printer

a) The installation shall include at least one printer as stipulated in the Project Specification and detailed in the relevant Data Sheet.

b) The printer shall be connected to the SCADA System's Local Area Network and accessible from all SCADA computers (server, workstation and engineering).

c) The printer shall be used for alarm and event message printing, measured value trend printing and operations and status report printing as well as any engineering change records.

d) The printer shall as a minimum be a colour laser or inkjet printer with specifications as stated in the relevant Data Sheet.

3.2.5 Uninterruptible power supply

a) All SCADA computers and peripherals shall be supplied from an Uninterruptible Power Source (UPS) which shall be an on-line synchronous (phase locked to supply frequency) single phase 230 V AC, 50 Hz, compact, self-contained UPS complete with full static bypass and all include necessary power circuitry, transformers, batteries, ventilation fan(s) and accessories.

b) The UPS shall be from a reputable supplier and shall be a standard catalogue item.

c) The UPS shall be sized for the full SCADA equipment load plus 25 % spare capacity, and shall be able to accommodate the inrush currents of all connected equipment.

d) The UPS shall be microprocessor controlled and be able to supervise critical functions and monitor circuit performance (such as temperature, battery status, mains fail, etc.). These shall be communicated to the SCADA system via a serial, galvanically isolated communications port to ensure correct management of the UPS and equipment connected to it under power fail conditions.

e) The UPS shall include visual indication of normal and abnormal operation as well as visual and audible indication of battery status.

f) The UPS shall be capable of maintaining the connected load fully operational for a minimum period of 30 minutes unless specified otherwise in the Project Specification or Technical Data Sheets. Longer back-up times shall be accommodated using additional Battery sets.

3.2.6 Networking Infrastructure

a) SCADA hardware interconnectivity and data communications network infrastructure shall provide for Level 1, 2 and 3 communications according to the standard Automation Hierarchy (i.e. Control, Supervision and Management communications respectively) and Industry standard data networks and protocols suitable for the offered control equipment (PLC, RTU, Instrumentation) shall be used, all as stipulated in the Project Specification and applicable Data Sheets.

b) The design and implementation of the networks as well as the selection of equipment shall comply with the Engineering Standard SPE-II-0003 – "Industrial Network Installation".

3.2.7 Earthing and Surge Protection

a) All computer hardware and peripheral power supplies including all data communications links shall be protected against the harmful effects of lightning and power line surges.

b) The entire installation shall be properly earthed, all equipment enclosures and surge arrestor ground terminals shall be bonded to a common earth bar; all as specified in the Engineering Standard SPE-II-0001 "General Electronic Installations".

3.2.8 Furniture

a) One purpose made SCADA Control Desk accommodating all of the required hardware and peripherals called for in the Project Specification and Technical Data Sheets, shall be supplied, delivered and installed as directed by the Engineer.

b) The Control Desk shall include a dust proof compartment in which the following shall be housed:

i) Operator workstation computer (excluding, keyboard and mouse)

ii) Dedicated UPS (unless a single, separate, floor standing UPS is called for)

iii) Printer(s), printer paper and ink cartridges. (The compartment shall make provision to store both the used and unused printer paper.)

c) Operator screens/ monitors shall be mounted in the vertical upstand section(s) of the Control Desk at ergonomical angles. All cabling shall be done neatly in the desk recesses and no cables other than the keyboard and mouse cables shall be routed outside of the desk.

d) The Control Desk shall further contain a section where the Employer's radio voice communications equipment and security surveillance equipment can be housed (if applicable).

e) If the control desk is situated in a plant area where dust and other harmful gases may be present, the control desk shall be maintained under positive pressure by means of a pressurisation fan. An easily removable and cleanable filter shall be installed to filter air before it is released into the enclosure.

f) Sufficient storage space shall be provided in the Control Desk for the works or plant Operations and Maintenance manuals Operator Log books, Report Files as well as any other general stationary.

g) SCADA Server Computers (where applicable) shall be accommodated in dedicated rack-mount type Computer Cabinets as stipulated in the Project Specification and relevant Technical Data Sheets.

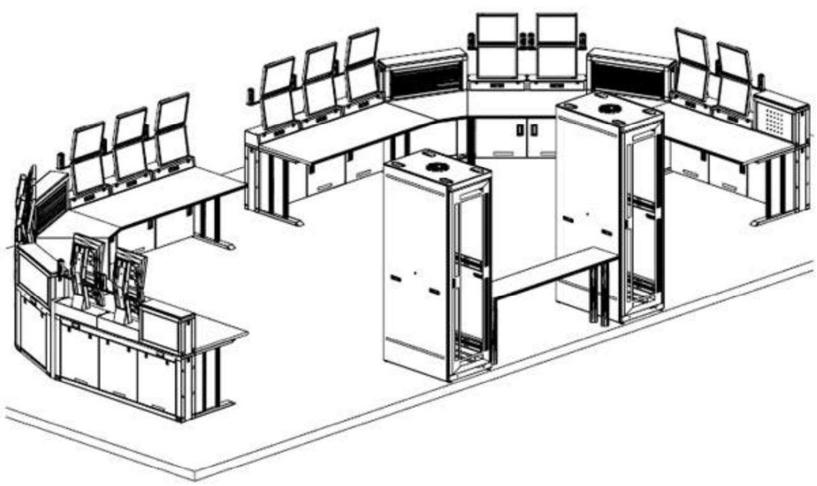

Figure 1: Typical layout of a large system Control Desks and Computer Cabinets

3.3 System Software

3.3.1 General

a) SCADA Software shall comprise of computer operating system software, hardware and peripheral drivers, SCADA specific applications (data acquisition, data storage, visualization and reporting) as well as general computer operations and maintenance software (e.g. anti-virus software, back-up software etc.).

b) Tenderers shall allow for all software in their offer and tender pricing, whether expressly specified or not.

c) Optional software available to enhance the system but not essential for the operations, and annual / versioning software revisions or additions beneficial for future extensions shall be shown and offered separately in the tender.

d) Software improvements and enhancements that occur within one year of the contract award date shall be furnished to the Employer at no additional cost.

e) All software shall have a proven industry track record with verifiable large user and technical support base.

f) All software supplied under this contract shall be registered and licensed to the Employer and the Contractor shall include proof of such licences in the Operations and Maintenance Manuals to be submitted on completion of the contract.

3.3.2 Computer Viruses

a) Unless the client has his own enterprise wide licence for Computer Anti-virus software or unless stated otherwise in the Project Specification, a copy of the latest OEM's (Original Equipment Manufacturer) anti-virus software shall be supplied and installed together with the OEM's operating system.

b) The anti-virus software package shall be of reputable manufacture with continuous update support to protect the system with the latest anti-virus technology.

c) The anti-virus software shall be provided preferably with an unlimited license linked to the Operating System License (e.g. Microsoft Security Essentials).

3.3.3 Computer Operating System

a) All SCADA computers shall be supplied with OEM versions of a suitable operating system (OS), which shall be a latest available real-time, multitasking, multithreading OS such as the Microsoft Windows OS that is compatible with the offered SCADA software unless specified otherwise in the Project Specification.

b) The operating system shall provide secure, integrated networking (LAN) features, protocols and services without the need for additional 3rd party networking software.

c) The SCADA historical and real-time database shall be accessible (read-only access) via the LAN interface for use in management information services and the Tenderer's offer shall include all database client access licences required for the offered SCADA system.

d) The operating system shall incorporate both a local and domain (work group) based security system with configurable users, groups and access permissions.

3.3.4 Special requirements

a) Under no circumstances shall it be possible to cause a system lockup, failure, or database contamination by operators entering spurious data or pressing the wrong sequence of keys or by accidentally leaning on the keyboard of the computer or any of its peripherals.

b) A "warm boot" (e.g. pressing the Ctrl, Alt and Del keys) shall be protected by means of a password.

c) Inputs by operators shall be vetted for spurious or incorrect data. Appropriate error messages shall be displayed in such cases.

d) In the case of a power failure (and subsequent run-down of the UPS) the system shall automatically shut-down saving all current status and data whereupon the system shall reboot automatically when power is restored and load the last stored status and data in order to continue normal operation. An alarm log entry shall be made stating the time and duration of the power failure.

3.3.5 Access authorisation

a) Operator access to both server and client computers shall be protected by means of the Operating System's passwords.

b) The OS security model shall provide for a hierarchy of user access by means of various user account levels, so that operators with a lower level of authority can only have access to basic operating functions, while operators with a progressively higher level of authority can have variable access including system administration and configuration functions.

c) It shall be possible to integrate the security models of server and client computers (e.g. Domain / Workgroup type security).

d) Once an operator has successfully logged onto the system with a valid password, he/she shall be able to change the password without changing the related access authorisation.

3.3.6 Real time clock synchronisation

a) The computer operating system(s) shall be capable of demanding a system date/time synchronising command from a local or network based time server and convey date/time synchronization to all connected field devices. The synchronisation shall take place automatically at least once per 24-hour period with a resolution of 1 second between all connected devices. A manual clock adjustment made on the SCADA server computer shall automatically activate the aforementioned procedure.

b) The system shall record each synchronisation into an event log including the time difference between the connected devices.

3.4 SCADA Application Software

3.4.1 General

a) The SCADA software package shall be a fully tested, supported and field-proven package suitable for Industrial automation purposes with a wide and well-established user base. Custom written software will not be permitted.

b) The software shall be supplied as a complete package for the application. No additional software or modules shall be necessary to configure or use all the features of the system. SCADA packages comprising a collection of software from various manufacturers (other than the computer operating system it is deployed on) will not be considered.

c) The SCADA software shall consist of scaleable, complementary, open architecture software objects that are user configurable to implement a complete functional SCADA in a modular fashion.

d) The SCADA software shall fully support and utilize the features of the operating system that it is deployed on (such as multi-tasking, multi-threading and security).

e) The package shall provide an extensive selection of communication protocol drivers to support various remote connected devices (PLC, RTU and Instrumentation).

f) The protocol drivers shall be robust and shall detect any communication failures to and from connected devices. Detected faults shall produce event/alarm failure signals for reporting.

g) The package shall be capable of a single user or multi-user (client / server) installation operating in a LAN configuration with the capability of having multiple workstations working simultaneously off a common database.

h) Process control logic will not be permitted in the SCADA package except where expressly specified or where written permission has been granted by the Engineer.

3.4.2 Data access methods

a) The SCADA shall support both polling and event oriented protocols for accessing data from connected field devices (PLC, RTU and Instrumentation).

b) The applicable protocol configuration(s) shall be as described in the relevant Telemetry and PLC Specifications.

3.4.3 Time and Date Stamping

a) The SCADA shall be able to accommodate and record externally time and date stamped data (data is time-stamped at the source device) as well as data that may require time and date stamping by the SCADA itself (such as operator actions and setpoint adjustments).

b) The SCADA database shall support data representation in any of the standard time formats (as selected via the Operating System Date and Time format settings) and use this for viewing, sorting and reporting of logged data.

c) All logic events, status changes and alarms shall time and date stamped in the field devices (PLC or RTU) and all SCADA commands, setpoint and parameter changes (including alarm acknowledgement) shall be time and date stamped in the SCADA.

3.4.4 Data processing

The SCADA Package shall be able to accommodate data from field devices (PLC, RTU and Instrumentation) in boolean, binary, word, integer or real number form.

3.4.5 Binary signals

a) Changes to the binary / boolean status of a signal shall be registered in the SCADA real-time memory, represented by its unique tag-name and the date & time of occurrence. This information shall be available and continuously updated for further processing, logging and report generation.

b) The system shall differentiate between two signal types, namely status signals and error/fault/alarm signals which have higher priority and automatic entry into the alarm log.

c) The system shall provide for binary signal priority processing, i.e. to exclude any signal from being logged or processed unnecessarily while maintenance is being performed to the system or a higher priority condition exists (e.g. inhibit run failure alarms on every motor when in reality a power failure has occurred).

d) Operator control commands shall be sent as binary signals. Commands shall be either momentary or latched. A latched command shall remain latched until reset by another command.

3.4.6 Integer signals

a) The system shall provide for the storage of equipment runtime hours in integer form, which shall then be used for maintenance reporting Analogue (real number) value processing.

b) Analogue/ Measured values (Instrumentation connected to a PLC or RTU or directly to the SCADA) shall be monitored and registered in the SCADA real-time memory, represented by it is a unique tag-name and its instantaneous reading. This information shall be available and continuously updated for further processing, logging and report generation.

c) The system shall allow for the following analogue processing:

i) Limit value monitoring (only on SCADA connected to RTU. For process control, limit value monitoring shall be done in the PLC).

ii) Strategy for substitute values - e.g. if a measuring range is exceeded (4-20 mA signal <4 or >20 mA) or if the signal transmitter or instrument is faulty, the system shall automatically generate an appropriate alarm and load a default substitute value and use it for further processing.

d) Special treatment during fault condition - by e.g. activating a fault indication and generating a fault alarm.

e) Real number outputs shall be used for assigning a limit value or setpoint to an analogue value processing in the PLC or for parameter setpoint changes in the PLC. It shall be possible to perform the following functions on the real number output:

i) Engineering conversion prior to output

ii) Setting cold start / default output values

iii) Setting output clamp limits

iv) Setting rate of change limits

f) The system shall provide for the following analogue value processing for report generation:

i) Totals (1 hour, 2 hours, 1 day, monthly, annual, etc.)

ii) Averages (1 hour, 2 hours, 24 hours, etc. averages)

iii) Extremes (minimum and maximum values for averaging periods)

iv) Integration of values, e.g. from a litres/sec value generates an integrated litres total value

v) Analogue value manipulation by means of the basic arithmetical functions e.g. summation of two inflow flow meter valves. The same functions shall be available for these derived values as for normal analogue values.

3.4.7 Counter values

Field devices shall process counter pulses and totalize values, passing them on to the SCADA system where the following processing modes shall be available:

a) Sum formation

b) Value manipulation by means of basic arithmetic functions

c) Generation of difference values (1 hour, 2 hours, etc. difference values)

3.4.8 Laboratory values

The system shall allow for entering laboratory measured values via suitably configured entry masks on the SCADA. Typical laboratory measurements will originate from portable instrumentation, manual chemical analysis and equipment run-time synchronization data after removal for maintenance.

3.4.9 Data Logging and Archiving

a) All measured values, events and alarms shall be written to a dedicated log file for long term storage on the SCADA server hard drive, database server or back-up media.

b) No data shall be automatically aged and/ or deleted from the SCADA database.

c) It shall be possible to set individual logging rates for each item of data depending on their rate of change and logging accuracy required, and archive the log files and / or database files at predetermined time intervals or on a demand basis.

d) Advanced users shall be able to easily retrieve and use archived data in any form (Plain Text, ASCII, Comma Separated Variables, Binary or Extensible Mark-up Language) using standard Microsoft products or any other third party data analysis software.

3.5 SCADA configuration for Process Visualisation and Operation

3.5.1 General

The SCADA package shall preferably provide scalable vector graphics support for the visual representation of the automated process. Operational elements of the process shall be represented by dynamic symbols in either of the standard formats such as TIFF, JPEG, BMP, WMF, PNG etc.

3.5.2 Process Mimics

a) SCADA mimic layout representing the process / plant shall be based on the works or plant Process Flow Diagrams (PFDs) as well as Piping and Instrumentation Diagrams (P&IDs).

b) Three dimensional equipment representation and plant layout as well as equipment animation shall be avoided unless it ads justifiable value to the SCADA operation AND has been approved by the Engineer.

c) The mimics shall be laid out to follow the flow of material through the plant / works.

d) The system shall allow for a hierarchy of mimics, beginning with a plant / works overview that progresses down to individual plant / works area overviews and finally individual equipment detail.

e) It shall be possible to navigate to the detail of an area or individual item of equipment by selecting it from any of the plant overview displays using either the mouse, keyboard or a touch sensitive screen / monitor.

f) All mimic displays shall be fully re-entrant meaning that the operator shall be able to proceed to any display without first having to backtrack via a previous higher level display mimic.

g) Each mimic shall have a ‘back’ button that would allow the user to return to the previous page.

h) The general mimic layout shall be subdivided into four basic sections as described below.

3.5.3 Navigation display line

A navigation section shall be provided to be used for easy navigation through the plant / works mimics and detail displays.

3.5.4 Message lines

A message line section shall be provided consisting of the three most recent operator messages. Messages shall typically consist of alarms and operator alerts.

3.5.5 Process visualisation (Mimics)

a) The process mimic section shall consist of a static background, (e.g. a tank with the associated pipe work), as well as dynamic symbols representing the related automated equipment (e.g. valves, pumps, mixers or level instrumentation associated with the tank). Measured values shall be displayed numerically and graphically. For example, the level in the tank shall be varied to emulate the real condition.

b) Equipment status, such as the operating condition of a pump, shall be displayed by variation of the graphic symbol representing the equipment, for example “green” when running and “red” when stopped.

c) Alarm values from discrete instrumentation shall be graphically displayed in a semaphore e.g. level alarms from a level switch shall be indicated on a pump sump to indicate “green” when healthy and “red” when activated.

3.5.6 Process control interface (Faceplates)

a) General

i) Each item of equipment in the plant or works that is automated, instrumented or otherwise monitored, shall be represented by an appropriate control faceplate (i.e. graphic display dialog) via which the operator can interact with that equipment.

ii) Separate faceplates shall be provided for PID loops and duty loops.

iii) Inputs by operators shall be vetted for spurious or incorrect data in which case appropriate error messages shall be displayed.

iv) In order to facilitate keyboard sequence entry it shall be possible to define macros, i.e. pressing a single key will be equivalent to a number of key entries.

v) The faceplate displays on the screen shall aid the operator in entering data from the keyboard.

vi) Additional “help” screens shall be provided, where necessary, to explain faceplate operation and key entry procedures.

b) Process operation

i) A unit for operation, for example a pump, shall be selected on the process mimic by means of the mouse and cursor. Left clicking the unit shall display its faceplate and allow entry of the required command(s).

ii) Once a faceplate has been activated, it shall show further detail about the equipment than just the mimic symbol change in colour. The faceplate shall display:

- the description and tag number of the unit
- the operating modes available for the unit (in plain text),
- the equipment status of the unit (in plain text)
- any static or variable operating parameters (e.g. controller setpoints, pump speed, current, alarm level etc.).
- a button to navigate to the trend for the equipment or control loop
- interlocks applicable to the equipment
- equipment reset buttons e.g. run hours reset

iii) The various possible operating modes shall be selectable by means of a graphic “pushbutton” or “selector switch” on the faceplate.

iv) After selection of the operating mode, the relevant symbol on the mimic shall change colour (e.g. border colours to represent modes), and the status text will change accordingly confirming the operator’s selection. Final acceptance of any instruction, data entry or selection shall always require a positive confirmation dialog.

v) Analogue and measured values, e.g. set points and limits etc. shall be entered on separate popup faceplates in a similar way. However the new numeric values shall be entered via the numeric keys of the keyboard.

3.5.7 Alarm message handling

a) The SCADA Alarm handling feature shall be configured to provide comprehensive fault and error annunciation, including acknowledgement and fault clearing procedures.

b) As soon as a fault or error occurs during normal operation, the respective area display shall start flashing, raise an audible alarm, and indicate a group alarm.

c) The operator shall be guided by the flashing area to the detailed mimic to which the fault has been localised, from where the operator shall be able to view and acknowledge the alarm and associated alarm text.

d) An audible alarm shall be provided with at least three different sounds / tones representing either high, medium or low priority alarm conditions. The alarm acknowledgement process, performed via the keyboard, shall silence the current audible alarm until a new alarm occurs.

e) Acknowledged alarm text messages that have not yet been cleared in the field, shall be displayed by means of a steady-state font colour. Only after the fault/error has been cleared/reset, shall the alarm text be removed from the list of current alarms.

f) All alarm messages configured in the SCADA shall be in clear and unambiguous text.

g) The operator shall be able to fully navigate and sort the alarm list, including acknowledged and unacknowledged alarm messages, and shall be able to filter items by type of fault or equipment type.

h) It shall be possible to define absolute value alarms for Analogue Inputs (in engineering units): HiHi, Hi ,Lo and LoLo as well as rate-of-change alarms.

i) The system shall be able to accommodate a minimum of 8 000 alarm messages at any one time. Once the limit has been reached, all acknowledged and cleared alarms shall be archived to make space for new alarms. Archiving shall also take place automatically once per day.

j) Error messages shall not take the form abbreviations, but shall consist of complete sentences or words.

k) A minimum of 8 priority levels shall be provided for alarms.

3.5.8 Trending

The SCADA configuration shall include for both live and historical colour graphical trends of all measured values (analogues) as well as select discrete states and instruments.

a) On-line (live) Trending

i) This function shall provide the ability to show live trends of analogue or calculated values. Each stored value shall be instantaneous or average values of a number of samples, depending on the desired resolution. The trend shall therefore span a fixed time period of 1 minute to approximately 60 hours depending on the average chosen. It shall be possible to display up to 8 values (in any combination e.g. digital, analogue, etc.) per trend page.

ii) The trend curves shall be fully configurable in terms of the line type, colour, axis scales, measurement units and numbering.

iii) Trends curves shall be printable in full colour, on demand or via the SCADA reporting feature.

b) Historical Trending

i) The system shall provide for historical trending curves to be displayed in the same manner as the live trends.

ii) The historical trending curves shall provide for range selection in the following standard configurations of the time axis.

- ¼ hour average - for daily historical trend curve
- 2 hour average - for weekly historical trend curve
- Daily average - for monthly historical trend curve
- Monthly average - for annual historical trend curve
- Actual value - updated every 6 seconds with the time axis full scale being selectable as 1 hour, 2 hours, 12 hours, 24 hours. The last one tenth of the display shall be updated and once it is full, the total curve shall be moved back one tenth, and so on.

iii) Trend curve shall include a navigation “slide” displaying the current values, minimum, maximum and average values over the trend range at the cursor position.

iv) The operator shall be able to freely select the beginning of the historical trend curve and he shall be able to spread the ordinate, thereby ”zooming” into or out of the trend.

v) Trend curves shall be displayable in bar graph or line graph format.

vi) Historical Trends curves shall be printable in full colour, on demand or via the SCADA reporting feature.

3.5.9 Reports

a) The system shall provide for an extensive reporting system, with output options to screen, file or printer.

b) Two broad categories of Reports shall be provided, being (1) external documentation reports and (2) operational information (instantaneous values, run hours etc.).

c) The external documentation reports shall contain the following minimum set of reports.

i) Daily detailed report and daily summary report

ii) Monthly detailed report and monthly summary report

iii) Annual report and annual summary report

iv) Fault/error/ alarm list (disturbance report)

v) Maintenance report

vi) Operator Alerts and Messages

d) The operational information reports shall include reports such as:

i) Analogue value status minimum, maximum, average and totalized values

ii) Binary value status

iii) Equipment modes and status

iv) Laboratory data

e) The operator shall be able to create custom free format reports by dragging and dropping selected information onto a report template. The printed document shall be an exact replica of the on-screen form when printed.

f) A report scheduler shall be provided enabling the operator to specify when any given report is to be generated and printed based on the time of day, day of the week or any given event.

g) Data for reports shall come from either the current live data in the SCADA memory or from historical trending log files or archived databases.

h) A separate operator message log shall be provided in the SCADA via which the plant manager and operators can capture, record and report on operational events, actions, problems and any other related messages.

3.5.10 Short Message Service (SMS) alerts

a) Unless otherwise specified in the Project Specification, the SCADA system shall include a GSM/3G modem with which the SCADA can alert the works / plant operational personnel when certain alarms or events have been triggered.

b) SMS messages shall be configured for up to 5 different recipients and message content as well as recipient contact numbers shall be freely configurable by the SCADA administrator.

3.5.11 Control System Functional Specification

a) The SCADA system shall be described in detail in a Control System Functional Specification produced by the Contractor for approval by the Engineer before configuration commences.

b) The following shall be included in this document:

i) Description of the SCADA hardware configuration

ii) Description of the SCADA software package

iii) SCADA mimic mock-ups (using any graphic tool)

iv) SCADA symbol definition (one for each type of equipment)

v) SCADA operator faceplate layout and definition (one per type of equipment, mock-up using any graphic tool)

vi) SCADA control modes

vii) Report Layouts

viii) Database design (if applicable)

ix) Trending screen layouts and grouping

x) SCADA Tag lists

xi) SCADA Alarm Lists

xii) SCADA security configuration

3.6 SCADA security

3.6.1 The SCADA system shall provide access security to prevent unauthorised access to the system and plant / works process. Securing the system through usernames and passwords shall prevent accidental reconfiguring by the process controllers and / or managers and provide a traceable log of all SCADA activity.

3.6.2 At least three levels of security shall be provided as follows, or as stipulated in the Project Specification.

a) Operators

Operators shall be required to logon to be able to perform their functions as follows:

i) View, Monitor and control the plant by navigating from mimic to mimic

ii) Stop, start and reset all equipment

iii) Change value settings

iv) View, Acknowledge and Reset alarms

v) Select, display, print and reconfigure TREND periods

vi) Print TRENDS

b) Managers

In addition to the permissions of operators, the managers must be able to perform the following functions:

i) Make controller parameter and /or control loop setting changes

ii) View the EVENTS list

iii) Reconfigure the EVENTS list

iv) Print the EVENTS list

c) Administrators/Engineering

Shall have access to all SCADA design time/ configuration menu items and functionality.

i) Operating System Task Manager

ii) Operating System Explorer

iii) Operating System User Manager

iv) SCADA Software Setup

v) SCADA communications Protocol Management.

3.6.3 The SCADA system shall be protected by a firewall, anti-virus software and access control system against unwanted external attacks.

4. INSTALLATION REQUIREMENTS

4.1 General

4.1.1 All SCADA equipment shall be installed in computer cabinets and /or in SCADA control desks (furniture) as described above.

4.1.2 The computer cabinets and control desk shall be physically located in a dedicated Control Room at the plant or works and the design and construction of the control room will be done by others unless stated otherwise in the Project Specification.

4.1.3 The control room (and server computer room where applicable) shall be air-conditioned by equipment provided under the separate contract which will also define the civil, structural (e.g. computer false floor), heating, air-conditioning, ventilation, small power and lighting requirements; unless stated otherwise in the Project Specification.

4.1.4 The installation, termination, earthing and lightning/ surge protection of the SCADA equipment shall conform to the requirements of the Engineering Specification SPE-II-0001 "General Electronic Installations".

5. TESTING AND COMMISIONING

5.1.1 The SCADA system shall be tested and commissioned as described in the Engineering Specification SPE-II-0001 "General Electronic Installations" with specific attention to the following:

a) During configuration, SCADA mimic displays, faceplates, trends and reports shall be electronically verified separately from the plant or works that it controls using a simulation environment.

b) SCADA to PLC / RTU / Instrumentation or other intelligent device communications shall be tested with the actual PLC/ RTU/ Instrument/ Device physically connected to the SCADA and the control software loaded onto that device, and with simulation of the physical I/O to those devices being monitored or controlled.

6. DOCUMENTATION AND TRAINING

6.1.1 Comprehensive documentation, training and operations & maintenance manuals shall be provided for the complete SCADA system provided under this contract for the plant or works, all as described in the Engineering Specification SPE-II-0001 “General Electronic Installations”.

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1. SCOPE

1.1 Application

1.1.1 This Standard Specification covers requirements for the supply, manufacture, delivery, installation, calibration, testing, commissioning and maintenance of instruments for the measuring of various process variables.

1.2 General Requirements

1.2.1 The completed installation shall incorporate all components and equipment necessary to reliably achieve the functionality defined in the Particular Specification / Technical Data Sheets / this Specification under all foreseeable conditions; whether or not they have been explicitly detailed, to provide the end user of the installation or the end user's nominated representative (hereafter referred to as the Employer) with a fully working installation.

1.2.2 All materials, components, and equipment used for the installation of instruments shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.

1.2.3 All equipment purchased shall have a minimum warranty of not less than 12 months. Equipment with replaceable spare parts shall be available for a purchase period of five (5) years from the date of acceptance of the system.

1.2.4 For complete definition of requirements, this Specification must be read in conjunction with the Scope of Works and Technical Data Sheets associated with the respective material requisition documentation.

1.2.5 This Specification serves as the minimum requirements to be followed to ensure that the design of the electrical, instrumentation and control systems satisfies the following project objectives:

a) Provide a fully instrumented and automated process capable of being controlled and monitored from a remote Control Room.

b) Wherever possible implement all control in the site-wide Process Control System (PCS).

1.2.6 Instrumentation shall be provided and installed in accordance with the Process and Instrumentation Diagrams (P&ID), and the Control and Instrumentation Cable Schedule to accomplish the required process control and feedback.

1.3 Installation Performance Requirements

1.3.1 The installation shall be suitable for its intended duty with respect to the electrical supply, distribution, and load requirements.

1.3.2 The installation shall be suitable for the environmental conditions, particularly with respect to corrosion resistance and ingress protection.

1.3.3 The installation shall be suitable for its intended location, particularly with respect to the mechanical properties and impact strength of the components parts.

1.3.4 The installation shall be compatible with existing equipment, plant, machinery and services.

1.3.5 The installation, including its circuit arrangements, shall satisfy the operational and functional requirements of the Employer and be readily and easily maintained throughout its operating life.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification identifies the Engineer's standard modifications and requirements, which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Particular Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.

2.1.2 The design, construction, installation, inspection, testing and commissioning of all instrumentation shall comply with all relevant Statutory Regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.

2.1.3 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed included.

2.1.4 The Contractor shall operate an approved, auditable quality assurance procedure covering the installation, inspection and testing of the various instruments.

2.2 Statutory Requirements

2.2.1 The instrumentation as incorporated on site, shall comply with the following:

a) Occupational Health and Safety Act of 1993

b) The law of the Republic of South Africa

c) Manufacturer's specifications and installation instructions

d) ICASA (Independent Communications Authority of South Africa)

2.2.2 All instruments shall be provided in accordance with current best practice and all applicable statutory and recognised requirements and standards, and shall be constructed and assembled with a high level of skill and craftsmanship.

2.2.3 The entire works shall be carried out in accordance with the requirements of all the relevant Government Acts and Regulations.

2.3 Recognised Standards

2.3.1 The latest edition, including all amendments up to date of tender of the following particular national and international specification, publications and codes of practice shall be read in conjunction with this specification and shall be deemed to form part thereof:

Table 1: Reference Standards

SANS Number	Description
SANS 10108	The classification of hazardous locations and the selection of apparatus for use in such locations
SANS 10142	Standard Regulations for Wiring of Premises
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 60730-2-15 & -2-18	Automatic electrical controls for household and similar use
SANS 60947-5	Low-voltage switchgear and controlgear Part 5: Control circuit devices and switching elements
SANS 61000	Electromagnetic compatibility (EMC)

SANS Number	Description
SANS 61643-1	Low-voltage surge protective devices Part 1: Surge protective devices connected to low-voltage power distribution systems - Requirements and tests
Other Standards	**Description**
BS 1646	Symbolic representation for process measurement control functions and instrumentation
BS 5863	Analogue Signals for Process Control Systems
BS 6739	Code of Practice for Instrumentation in Process Control Systems: Installation Design and Practice
BS 7405	Guide to the selection of an application of flow meters
BS EN 837	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
BS EN 1092	Flanges and bolting for pipes, valves and fittings
BS EN 12449	Copper and copper alloys. Seamless, round tubes for general purposes
BS EN 50288	Multi-element metallic cables used in analogue and digital communication and control. Generic specification
BS EN 60534	Industrial-process control valves. Dimensions. Face-to-face dimensions for rotary control valves except butterfly valves
BS EN 60770	Transmitters for use in industrial-process control systems. Methods for performance evaluation
BS EN 61010	Safety requirements for electrical equipment for measurement, control and laboratory use. Safety requirements for hand-held probe assemblies for electrical measurement and test
BS EN ISO 5167	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full. Orifice plates, nozzles, and venturi tubes inserted in circular cross-section conduits running full
BS EN ISO 6817	Measurement of conductive liquid flow in closed conduits. Method using electromagnetic flow meters
DIN EN ISO 7027	European standard for turbidity measurement of potable water.
BS EN ISO 9906	Rotodynamic pumps. Hydraulic performance acceptance tests

3. GENERAL INSTALLATION REQUIREMENTS

3.1 Overview of Requirements

3.1.1 All instruments shall be suitable for operation on a single phase, 50 Hz alternating power supply and environmental conditions as per project description and general information.

3.1.2 The instrument enclosure shall house the instrument monitor, power supplies and the required EMI/RFI surge suppressors. A local isolator shall be provided in the instrument enclosure to isolate the instrument.

3.1.3 All instruments shall be equipped with a local indicator, indicating the process variable being measured.

3.1.4 All instruments shall be equipped to generate an isolated 4-20 mA output proportional to the process variable being measured.

3.1.5 All instruments shall be supplied complete with a suitable pedestal for mounting the instrument enclosure at 1 200 mm above finished ground level and all the required mounting brackets and material for the enclosure and all the required transducers.

3.1.6 Hand rails or kick rails shall not be used for mounting of equipment, control devices, cables or conduits. Control stations and field mounted panels shall be positioned such that there is a 600 mm wide clear access way to the panel and a 600 mm clear space around the front of the panel. The clearances are required to a height of 2 000 mm.

3.1.7 Instrumentation installed on the front of control panels shall generally be located at a suitable working height (1 400 mm above floor level). The respective electrical wiring shall not interfere with the normal operation or opening of other panel equipment.

3.1.8 Brackets, supports, bolts, nuts, washers, pedestals or any other load bearing devices shall be stainless steel and protected against corrosion related to climatic weather conditions, and/or the location of installation with respect to the process environment.

3.1.9 Pipework shall be stainless steel or HDPE with compression type couplings.

3.1.10 Wherever possible, the instruments shall be located so that they are protected from damage by passing or falling objects.

3.1.11 All outgoing and incoming signal lines (excluding transducer signal lines) shall be free floating, i.e. ungrounded at the instrument. All these signals will be centrally grounded at the main control room or field processing unit.

3.1.12 All instruments supplied shall have a proven track record in Southern Africa under similar operating conditions.

3.1.13 The equipment shall be designed and installed to operate continuously at the specified rating for 24 hours per day, 7 days per week at the operating conditions specified. Unless otherwise specified, the equipment shall have a design life of 15 years with only routine maintenance required.

3.1.14 Preference is the provision of one programmable logic controller (PLC) per process cell instead of multiple small individual PLC's per supplied unit.

3.1.15 The installation shall be a highly reliable, safe and efficient system with fault and diagnostic reporting capabilities.

3.1.16 Minimal onsite instrument and control system installation and testing will be allowed. Contractors shall bench test and pre-calibrate instrumentation and equipment as far as possible prior to delivery.

3.1.17 Wherever possible the electrical, instrumentation and control system components shall be pre-assembled, pre-mounted and pre-wired to junction boxes prior to being transported to site. These pre-assembled components shall be completely calibrated and tested prior to shipping unless otherwise noted in the Particular Specification.

3.1.18 Standardised equipment shall be supplied as far as possible to minimise spares. Standardisation of process control deliverables, design documentation and software for the whole plant (including all equipment and packaged plant Manufacturers) is required. Standardisation shall be undertaken in such way that process efficiency and accuracy is maintained to the required levels and that actual 'whole of life cost' is considered when selecting and standardising the plant equipment design.

3.1.19 All instruments and control devices including dedicated equipment controllers supplied with the mechanical equipment shall be capable of integration with the PLC. If the package includes a controller all parameters and information needed to control and monitor the unit/process cell should be made available to the plant-wide control system. The Contractor is required and shall allow time to attend software coordination meetings.

3.1.20 The provision of all hardware and software integrated in a Manufacturer's package control system for the purpose of interfacing to the overall control system is the responsibility of the Contractor. All associated hardware and software required to complete the interface shall be documented in the Contractor's preliminary design documentation for review by the Engineer.

3.1.21 The Contractor shall provide representation to be involved in the control system design review to ensure that the selected solution and the proposed implementation methodology satisfy the requirements of the equipment supplied under the scope of supply.

3.1.22 Wherever practicable all control circuits and instruments shall be designed so as to be fail safe in the event of power, equipment or wiring failure.

3.1.23 The transmitter shall be mounted separate from the sensor and shall have local indication where specified in the Instrumentation and Control Cable Schedule.

3.1.24 The Contractor shall supply all the plant, equipment, fittings, mountings and brackets necessary to install, test and commission all instrument related products covered by this Contract.

3.1.25 The Contractor shall factory mount, pipe, tube and wire all instrumentation to the maximum extent possible. Only items that cannot be factory assembled or are subject to transport damage shall be shipped loose for field assembly.

3.1.26 Where openings through walls are provided for the Contractor to install pipe work (such as for sample water flow for the inlet pH and turbidity meters), the Contractor shall grout these openings closed after installation of the pipe work, ensuring a neat finish that matches the surrounding wall.

3.1.27 Where the diameter of the meter offered differs from the pipe diameter specified, the Contractor shall provide matching diameter pipes on either side of the flow meter, as well as suitable reducers and support brackets to enable the meter to be installed in the line. All couplings and flanges of flow meters installed in manholes/chambers shall be wrapped in Denso Tape.

3.1.28 All mountings, brackets, and pedestals shall be stainless steel.

3.1.29 Pipework shall be stainless steel or HDPE with compression type couplings.

3.2 Environmental Exposure

3.2.1 Throughout the construction period, all equipment shall be adequately protected against adverse climatic conditions and mechanical damage.

3.2.2 All instrumentation shall be designed for use in the aggressive environment encountered at a wastewater treatment works in a corrosive environment. Equipment shall be robust and simple to maintain. Equipment shall be manufactured from non-corrodible materials suitable for the application.

3.2.3 The transmitter unit of the instrumentation shall be installed indoors or in a weatherproof housing.

3.2.4 All instrument monitors shall be mounted in a weatherproof enclosure offering a protection of IP 65. The enclosure shall be padlockable and shall be equipped with a shatterproof-armour plated glass insert so that the local indicator can be read without opening the enclosure. Each glass display window shall be equipped with a shield protecting the display from direct sunlight.

3.2.5 Unless otherwise specified, the Contractor shall assume that the supplied equipment shall be installed outdoors and exposed to an environment of direct sunlight, rain, dusty atmosphere and salt laden air, and that the supplied equipment will be subjected to spillage of process liquids and splashing from high pressure wash-down water and in sections of the process plant, to corrosive liquids.

3.2.6 Non-metallic covers shall be UV stabilised long life type.

3.2.7 Sensors/detector heads shall be rated IP 68 for environmental protection and shall be able to be flooded.

3.3 Units of Measure

3.3.1 All units shall be expressed in SI (System International).

3.3.2 All piping sizes shall be expressed in nominal sizes: DN (diameter nominal) - mm.

3.3.3 Instrument tubing shall be in metric units.

3.4 Preferred Equipment List

3.4.1 A list of all proposed instrumentation and control equipment shall be provided to the Engineer for review prior to any associated procurement or construction.

3.4.2 The Contractor shall advise if there are any significant implications in terms of time, surety and value-for-money in using items other than stated in the Technical Data Sheets.

3.4.3 The Contractor shall note that the Engineer reserves the right to modify including further reduce the number of instrument and electrical equipment Manufacturers and limit models or to select a specific manufacturer / model for each equipment type to provide conformity across the Site at any stage of the project.

3.4.4 Wherever practical, the Contractor shall standardise selection and supply of instrumentation and control equipment to minimize the required number of final spares to be provided. Equipment purchased shall generally be standard items with minimal delivery periods and accessible spares availability.

3.4.5 If non-standard control equipment is approved by the Engineer, the Contractor will be responsible for the integration of this non-standard hardware in the overall control system. This is not limited to the supply of all hardware and developing the software to establish communication between the relevant PLC's.

3.5 Controller Programming

3.5.1 The Contractor is responsible for the control system software development for all controllers provided in their scope of supply.

3.5.2 Contractor control system development shall include:

a) PLC programming to control equipment and process within their scope of supply

b) The configuration of the controller to facilitate monitoring and control of the Manufacturer's package from the control system

c) Operator interfaces required to monitor and control the equipment and process.

3.6 Operator Interface Programming

3.6.1 All Human Machine Interfaces (HMI's) shall be integrated to the control system.

3.6.2 Based on the complexity of their packages control and monitoring requirements, Contractors shall provide a suitable operator interface for equipment within their scope of supply.

3.6.3 Contractors shall provide samples of their packages HMI to the Engineer for review and authorisation prior to complete system development.

3.6.4 Where the equipment included in the scope of supply includes a controller without an operator interface, the Contractor shall provide all necessary information to allow operator interface development by a third party.

3.6.5 Data logging and retrieval of equipment signals shall generally be performed by telemetry outstation/master station facilities. Where telemetry facilities are not available then solid state chart recorders with memory card logging or portable logging devices shall be used.

3.7 Equipment Numbering

3.7.1 All electrical equipment and instruments shall be identified with a unique instrument / equipment tag number according to the Particular Specification or Process and Instrumentation Diagram.

3.7.2 These tag numbers shall be used to identify the instruments / electrical equipment on the equipment itself and mounting locations.

3.7.3 Tag numbers shall carry through the entire design, appearing consistently on drawings, manuals, documents, labels, controller software, operator interfaces and data management systems.

3.8 Instrument Tags and Nameplates

3.8.1 All instruments, transmitters, control valves and pushbutton stations shall have a nameplate fitted to the instrument stand or adjacent structure.

3.8.2 Equipment shall be labelled clearly and visibly using black lettering on white background traffolyte labels fixed by at least two (2) stainless steel screws. Lettering size shall be not less 6 mm high.

3.8.3 Name plate wording shall be in accordance with the project standards.

3.9 Instrument Power Supplies

3.9.1 Instrument power supply shall be 24 V DC for all loop powered instruments.

3.9.2 Only where 24 V DC is not an option, and where approval from the Engineer has been received, shall 230 V AC be used for non-loop powered instruments. All four-wire devices and analysers, however, shall be powered using 230 V AC.

3.9.3 Loop powered instruments shall be powered from control system panels.

3.9.4 Non-loop powered instruments shall have individual miniature circuit breakers for protection, in Control panels or field stations.

3.10 Process Isolation

3.10.1 Isolation valves shall be provided so that valves and instruments can be removed for maintenance without draining tanks or reservoirs and without depressurising entire systems.

3.10.2 The first isolation valve for instrument connections shall be a full process rated piping valve (not an instrument valve).

3.10.3 Separate process connections are required for each instrument, including pressure gauges.

3.10.4 Process connections for instruments on vessels shall be dedicated to the instrument (Instrument bridles are not permitted) and not shared with process piping.

3.11 Junction Boxes

3.11.1 All signal wiring, and power wiring that enters or leaves a skid or a package system shall be terminated in frame mounted junction boxes.

3.11.2 Separate junction boxes shall be provided for instrument signals, non-instrument signals and power supply cables.

3.11.3 Analogue and digital signal cabling may be installed within common junction boxes.

3.11.4 Similar signal types shall be grouped to avoid electrical interference between signals and to allow the Contractor to easily connect cables to the terminals.

3.12 Moving and Shipment

3.12.1 Removal of instrumentation shall be avoided wherever possible by provision of adequate tube, cable, instrument supports, brackets and structure and installation of additional temporary structure for transport. The Contractor’s installation shall also facilitate disconnection and reconnection by convenient location of junction boxes, and piping / tubing breaks.

3.12.2 Some instrumentation may still however require partial disassembly for protection against vibration, environment, (sea) transport and handling damage.

3.12.3 All equipment, panels and cables shall be fully sealed for transport.

3.12.4 A full set of erection, reassembly and testing instructions shall accompany the equipment.

3.12.5 Instrument installation shall be consistent with the project standard instrument installation details issued by the manufacturer.

3.12.6 Loose instruments shall be separately packed in shipping crates that are dust-tight, moisture-resistant, and substantial enough to withstand ocean shipment and warehouse handling, and to prevent damage to equipment.

3.12.7 Instruments shall be tagged to match the instrument number to the project standard.

3.12.8 All electrical, electronic and electro-mechanical equipment shall be protected against ingress of moisture during shipping.

3.12.9 Packing shall allow for thermal expansion and contraction during transport and storage.

4. LIGHTNING AND SURGE SUPPRESSION

4.1 General

4.1.1 All instruments shall be protected against lightning and other EMI/RFI in the following way:

a) The power supply to the instrument shall be protected at the instrument by means of line surge voltage protection unit.

b) The instruments shall be protected against surges on all outgoing and incoming signal lines.

c) Loop isolators or surge suppressors of the instrumentation cabling shall also be provided at the PLC.

4.1.2 In addition to the above, all outgoing and incoming signal lines shall be protected by means of a plug-in fuse with light indicator.

4.1.3 Surge protection devices shall be provided at both ends of the 4-20 mA signal cables and digital data lines that clamp the voltage to no more than 45 volts. Each device shall be securely bonded to the earthing system. The case of each transmitter and each receiver shall be connected to the earthing system.

4.1.4 Remote transmitters shall use a local earth system.

4.1.5 Surge protection devices are not required if the signal loop:

a) Does not extend outside of the switchboard or

b) Does not extend outside the confines of a building

4.1.6 Surge protection devices shall be of the series connected type, comprising of three stages of protection, failsafe operation (fail to short circuit), common and differential mode protection.

4.1.7 Metal instrument cases and panel sections shall be earthed, where possible, by metal to metal contact through their supports. Where this is not possible, a green/yellow PVC insulated 2.5 mm^2 copper wire shall be used to connect the case to the nearest electrical earth bar.

5. FIELD SENSORS

5.1 General requirements

5.1.1 Process sensors (i.e. ph electrodes, electronic dip devices, chlorine sensors etc.) shall be located as close to their relevant transmitters as reasonably practicable. The sensor signal cable shall where possible avoid areas of extraneous interference (e.g. EMI, RFI). Strict observance shall be made to cable segregation and installation requirements.

5.1.2 Where sensors are required to be installed in pumped sample lines, the length of sample pipe work from the process main to the sensor shall be kept to a minimum. Pumped sample flow rates shall have a minimum velocity of 1.0 m/s and a maximum velocity of 1.5 m/s, and appropriate filtering shall be installed to protect the sensor from mechanical damage and electrode poisoning.

5.1.3 The sensor location shall generally be installed in a turbulent free environment following the Manufacturer's recommendations for the number of diameters of straight pipe lengths upstream and downstream of any restrictions.

5.1.4 The sensor shall not be installed in areas where excessive temperatures are anticipated. Where additional by-pass pipe work is required then adequate valve arrangements shall be installed to ensure effective isolation of the sensor.

5.1.5 Transmitted analogue outputs for recording, monitoring and control shall generally be 4-20 mA.

5.1.6 Where the installation is located in PVC pipe work and is adjacent to potential sources of EMI, then adequate earthing arrangements shall apply local to the magnetic flow meters (i.e. ground earth rods).

5.1.7 The installation of 'wet' sensors and process pipe work into electrical control panels is strictly forbidden.

6. FLOW AND LEVEL

6.1 General requirements

6.1.1 Any type of flow meter that is technically suited for the application may be considered for flow measurement.

6.1.2 All flow measurements expresses as ratios or that are cascaded with other process variable shall be linearised.

6.1.3 All flow meter runs shall have connections for static pressure and fluid temperature measurement. These connections shall be located at least 8 pipe diameters downstream of the primary measuring device.

6.1.4 Flow element shall be sized so that:

a) Normal flow rate falls at approximately 70 % of maximum scale range

b) Minimum flow is not less than 30 % of maximum scale range

6.1.5 The calculations for flow elements shall be done at the following standard reference conditions:

a) Flow liquids - 101,325 kPA abs @ 20 ºC

b) For gas and vapours - 101,325 kPA abs @ 0 ºC

6.2 Orifice plate flow installations

6.2.1 The upstream and downstream lengths of the orifice meter tubes for all applications shall be according to ISO 5167.

6.2.2 Prefabricated meter tubes shall be mandatory only if a 2 % or better accuracy in measurement is required by the process and when it is not possible to obtain this accuracy using field fabricated meter tubes made from available materials at local facilities.

6.2.3 The length of prefabricated meter tubes shall as a minimum be 15 D upstream and 7 D downstream from the orifice flange face. (Where D = pipe diameter).

6.2.4 Orifice plates shall be installed between weld neck orifice flanges, of which the material shall be according to line class.

6.3 Electromagnetic Flow Meters

6.3.1 General

The instrument shall be of a type suitable for application in raw sewage and activated sludge. It shall have high stability properties and shall require negligible maintenance over extended periods.

The flow meters shall comprise:

a) Detector head

Locally mounted control unit/transmitter, with display of current and accumulative flow (in litres per second and kilolitres respectively). The control unit shall generate a 4 – 20 mA signal proportional to the flow reading, suitable for transmission to a remote PLC (up to 1 000 m away). If mounted outdoors, the control unit shall be mounted in a weatherproof box, with a shield protecting the glass display window from direct sunlight.

b) All power supply and signal cabling

c) All mountings, brackets, pedestals etc., required to install the equipment

6.3.2 Operating principle and construction requirements inauguration

a) The electromagnetic flow detector shall consist of a length of smooth bore pipe having an equal internal diameter to that of the pipeline into which it is to be installed. This pipe insert shall be non-magnetic and lined throughout its bore with an electric insulant. A magnetic field shall be generated across this pipe insert and the two diametrically opposing electrodes shall detect the voltage generated when liquid flows through the field. This generated voltage shall be amplified by a remotely mounted amplifier and converted to an electric signal suitable for receiving instruments such as indicators, recorders, integrators and controllers.

b) All electromagnetic flow meters shall consist of a separate detector head and amplifier.

c) The detector head shall be of a robust construction and shall suffer no harmful effects if submerged, i.e. protection of enclosure to be IP68.

d) The detector liner shall be of hard wearing ebonite rubber suitable for sewage water applications and shall extend over the flange faces.

e) The detector head electrodes and earthing discs (to be supplied with the instrument) shall be made of stainless steel grade 316 or better.

f) The electrodes shall be automatically cleaned. Any build-up of fats and other debris on the electrodes shall not influence the operation of the instrument. In the selection of the instrument due cognisance shall be taken of the potential fatty nature of sewage water.

g) The amplifier shall be mounted in the previously described instrument enclosure, together with the previously specified auxiliaries such as surge suppressors, etc.

h) The amplifier shall be equipped with a digital current rate of flow indicator (in litres per second), preferably of the LCD type, a non-resettable flow totaliser (in kilolitres or cubic metres), a galvanically isolated 4-20 mA output linear to flow and an isolated pulsed output for remote flow totalising.

i) The instrument shall have a variable span facility with automatic zero control and a signal hold facility.

j) The instrument shall preferably operate on a pulsed DC field or other means to reduce power consumed and prevent electrode polarisation and zero drift.

k) The magnetic flow meter shall be capable of withstanding the test pressure experienced during mains testing without impairing operating performance.

6.3.3 Installation requirements

a) The control unit shall be mounted in a weatherproof box, with a shield protecting the glass display window from direct sunlight. The instrument enclosure shall be pedestal mounted adjacent to the flow chamber 1 200 mm above natural ground level.

b) A removable pipe section of adequate length will be provided by the piping Contractor. This pipe section will be flanged on one side and will be supplied with a coupling on the other side. The Contractor will be required to shorten the pipe insert to accommodate this flow meter head. Before ordering the detector head, the Contractor shall ascertain the flange details of the pipe supplied so that the detector flanges and pipework flanges match.

c) Where the flow in the pipe is too low for the flow meter to register, a flow meter with smaller diameter shall be considered and approval obtained from the Engineer.

d) Where the diameter of the flow meter is not exactly the same as the internal diameter of the pipe in which it is to be installed, the Contractor shall provide suitable length matching diameter pipes on either side of the flow meter, as well as suitable reducers (with maximum angle of 8º) and stainless steel support brackets. All couplings and flanges shall be wrapped in Denso Tape.

e) The lining of the flow meter head shall not be used as a gasket. Suitable gaskets shall be provided and installed between the flow meter head, earthing rings and adjacent pipe work.

f) A suitable local earth shall be provided by means of 1,8 m copper earthing electrodes. Sufficient electrodes shall be provided to obtain an earth resistance of less than 1 ohm.

g) Where magnetic flow meters are installed then dual earth rings with earthing straps shall be installed at either end of the meter flange face. The earthing straps shall be attached to the process pipe work and shall provide earthing continuity.

h) The instrument installation shall include all interconnections and sundry requirements between sensor and control/amplifier unit.

i) Magnetic flow meters shall be rated for continuous submergence to 5 m depth, and shall be suitable for installation buried underground.

j) Magnetic type flow meters installed in manholes/chambers shall be rated with Type IP68 Environmental Protection, and shall be suitable for installation buried underground.

k) When the magnetic flow meter is installed in manholes/chambers, the Contractor shall provide details to the Civil Contractor on how the manholes and chambers should be constructed. In each chamber two reducers should be installed one flanged the other plain ended, normally done by the Civil Contractor, which should be based on the flow meter supplied. The reducers shall be fabricated with an 8º angle, and will be temporarily joined by the Civil Contractor with a spool-piece.

l) The Contractor shall be responsible for dealing with any water in the pipelines in order to install the flow meters (the pipelines may be in use before the flow meter installation takes place), and for removing the respective temporary spool-piece and delivering it to the Employer's store.

m) Included with the flow meter, the Contractor shall provide the necessary pipework, fittings and supports to fit the flow meter to the reducers such that flexibility for removal of the flow meter is allowed and that the required accuracy of measurement is achieved."

n) The flow meter chamber shall drain by gravity to the nearest storm water manhole or catchment area with pipe of minimum 50 mm diameter.

6.3.4 Accuracy

The accuracy of the instrument shall be guaranteed to be equal or better than:

a) ± 0,5 % of measured flow in the flow range 50 – 100 %

b) ± 0,1 % of full scale for flows in all other ranges

The repeatability of the instrument shall be better than 0,1 % of full scale deflection and the linearity of the instrument shall be better than 0,05 % of full scale deflection.

6.3.5 Maintenance

The instrument shall be maintenance free.

6.4 Ultrasonic Open Channel Flow Meters and Level Meters

6.4.1 General

a) All ultrasonic open channel flow meter shall be microprocessor based, non-contact level meters and be able to be programmed to read flow accurately passing through any type of flume or over any type of weir, or to read level/volume accurately in an irregularly shaped container.

b) When measuring flow through a flume, the measured flow shall be based on the level in the approach section to the flume.

c) Before calibrating the flow/level/volume rates, the Contractor is to take accurate measurements with the help of a laser (accurate to 1 mm) of the relevant civil structure used for installation. The exact structure size must be used for programming the controller, especially when new instruments are installed on existing flumes/weirs.

6.4.2 Operating principle

A burst of ultrasonic pulses are transmitted from a transducer head, which is not in contact with the medium. These pulses are reflected of the top surface of the medium and received by the same transducer. The time delay between the transmitted and received signal is proportional to the level between the transmitter/receiver, which is fixed, and the medium, which is variable, since the level can be calculated. To compensate for the temperature dependence of the ultrasonic signal, the air temperature shall be measured at the transducer and shall be taken into consideration when the level difference is calculated between transmitter and medium.

6.4.3 Constructional requirements

a) The ultrasonic transducer shall include a built-in temperature sensor and shall have a minimum enclosure rating of IP 65. The transducer shall be corrosion protected as well as immune against UV radiation.

b) The level calculation shall be temperature compensated.

c) For flow application, the instrument shall provide for the following standard primary flow elements:

   i) Venturi flumes

   ii) V-notched weirs

   iii) Parshall flumes

   iv) Broad crested weirs

d) Any special obstruction with a known relationship between height of medium and flow rate. (For this purpose a ten point lock-up table with linear interpolation is deemed satisfactory)

e) For flow applications, the instrument shall be equipped with a local flow rate indicator and an 8 digit controller. If the controller is fed from the microprocessor, it shall be supplied with a minimum of 24 hour battery backup to prevent data loss in the event of power failure.

f) In addition to the above, for flow meter applications, a galvanically isolated pulsed output shall be provided to the remote controller.

g) A galvanically isolated 4-20 mA output, linear to flow or level shall be provided for remote indication and processing.

h) Where no stilling well is provided as part of the measuring structure, a suitably dimensioned stilling well shall be supplied as part of the instrument.

i) The control unit shall be supplied complete with battery backup to prevent against loss of set-up data in the event of a power failure.

6.4.4 Installation requirements

a) The ultrasonic transducer shall be supplied complete with mounting bracket and frame. The mounting frame shall be rigid and made from stainless steel. The transducer shall be mounted in such a way that it is free from all handrails, walkways, etc. Passing traffic and the operation of other machines in the vicinity of the transducer shall have no influence on the transducer.

b) Where required in the opinion of the Engineer, a suitably dimensioned stilling well shall be supplied and installed.

c) The Contractor shall conform to the manufacturer's recommended instructions for the positioning and mounting requirements for the installation of the insertion flow meter.

d) The installation shall include for all required interconnections and sundries between the sensor and control unit.

6.4.5 Accuracy

The accuracy of the level measurement shall be better than 0,25 % of full scale.

6.5 Averaging Pitot Tube Gas Flow Meters

6.5.1 General

The instrument shall be suitable for measuring flow in sewage/sludge digester gas. The digester gas consists mainly of methane gas (CH4), moisture, sulphurous and other impurities. The primary flow element shall impose a minimum permanent pressure loss.

6.5.2 Operating principle

The flow sensor shall measure the average dynamic plus static pressure (average high pressure) and the average static pressure (average low pressure) in the flow stream. The difference between the average high and low pressures gives the dynamic pressure with which, in accordance with the Bernoullis theorem, the flow rate can be calculated.

6.5.3 Construction

a) The flow sensor shall span the total pipe diameter.

b) The flow sensor shall be symmetrical to facilitate bi-directional flow measurement.

c) The required number of parts shall be calculated in accordance with the pipe diameter to achieve maximum stability and accuracy.

d) The port locations shall be determined as per Chebyshev calculus for correct averaging.

e) The flow sensor shall be shaped to establish a fixed separation point of the medium on the sensor to eliminate any shift in the low pressure signal that can cause a loss of accuracy. The design of the sensor shall be such that it's accuracy is not influenced by fouling the sensor surface through impurities in the gas. Round sensors are therefore unacceptable.

f) The flow sensor shall be constructed out of high grade stainless steel.

g) The flow sensor shall be designed and installed that it can be installed, removed and reinstalled without system shutdown.

h) The instrument shall be supplied complete with differential pressure transmitter and a control unit giving a linear local rate of flow indicator and a flow totaliser.

i) The instrument shall generate a galvanically isolated linear to flow 4-20 mA output for remote indication and calculation.

j) A galvanically isolated pulsed output shall be generated by the instrument for remote totalisation.

k) The control unit, power supplies, indicators and signal generators shall be mounted in the previously detailed instrument enclosure.

6.5.4 Installation

a) Where the instrument is to be installed in a non-metallic pipe, the scope of supply shall include the replacement of a suitable length of pipe in stainless steel or copon coated mild steel with the necessary fittings attached to the pipe.

b) Where the installation is to be made on a metallic pipe, the scope of supply shall include for the provision and installation of all required fittings on the main pipe.

c) In all cases, the instrument shall be supplied and installed complete with all isolating valves, insert and restart mechanisms, instrument connections, instrument pipe work and instrument valves to give a complete working and serviceable installation.

6.5.5 Accuracy

An accuracy of better or equal to ± 1 % shall be maintained over a flow turn down of greater than 10 to 1, independent of the Renolds number. The repeatability of the instrument shall be equal or better than ± 0,1 %.

6.5.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

6.6 Flow Switches

6.6.1 Flow switches shall be of the calorific (thermal) type.

7. PRESSURE

7.1 General requirements

7.1.1 Pressure element materials

The wetted parts of process pressure measuring instruments shall be made of 316 stainless steel unless dictated otherwise by the nature of the process. Alternative materials are acceptable on instrument measuring pneumatic lines.

7.1.2 Suppressed range or elevated range instruments

a) Suppressed range or elevated range pressure measurement instruments shall be furnished where necessary to provide additional measuring sensitivity for control purposes.

b) Each installation with an instrument having an elevated or a suppressed zero shall have a pressure gauge that can indicate actual pressure during start-up and shutdown.

7.1.3 The pressure instrumentation shall be able to withstand a continuous over pressure of 200 % of maximum process static pressure.

7.1.4 Pressure Transmitter

a) Instrument shall be indicating, electronic type based on capacitance principle.

b) The instrument shall be “smart unit” that would allow calibration and diagnostic checking by hand held calibrator.

c) Instrument shall have local display of pressure.

7.1.5 Differential Pressure Transmitter

a) Transmitter shall be indicating, electronic type based on capacitance principle.

b) The transmitter shall be “smart unit” that would allow calibration and diagnostic checking by hand held calibrator.

c) Instrument shall have local display of differential pressure.

7.1.6 Mechanical Pressure Gauges

a) Analogue mechanical or bourdon tube pressure gauges shall be of the bottom entry type and shall have a face of at least 60 mm in diameter with clear, readable markings and indicators. Details in this regard shall be supplied by the Contractor in the operation and maintenance manuals.

b) The indicated range on the gauge shall span 120 % of the operational pressure range specified for the relevant equipment. Accuracy shall be within 3 % of the full scale deflection value. An adjustable indicator shall be set to indicate the maximum operational system pressure clearly.

c) It shall be possible to isolate the pressure gauge from the pipe pressure by means of a valve or a gauge cock, which shall be supplied and installed by the Contractor and shall be included in the tendered rate for the equipment.

d) A gauge protector shall be fitted where a gauge has to indicate pressures in corrosive media or liquids that could easily clog the pressure ports. It is a requirement that gauge protectors be fitted where sludge is the working medium.

e) Pressure gauges fitted to hydraulic pipe lines shall be glycerine-filled for damping purposes, and gauges fitted to pneumatic or gas pipelines shall be vacuum damped.

7.1.7 Pressure Switch

Pressure switches shall be of the Diaphragm type.

8. ANALYTICAL INSTRUMENTS

8.1 Dissolved Oxygen Meters

8.1.1 General

The instruments shall be of a type specially developed for application in wastewater and actuated sludge. It shall have high stability properties and shall require negligible maintenance over extended periods.

8.1.2 Operating principle

a) The sensor shall be coated with a luminescent material. Blue light from an LED is transmitted to the sensor surface. The blue light excites the luminescent material. As the material relaxes, it emits red light. The time from when the blue light was sent and the red light is emitted is measured. The more oxygen that is present the shorter the time it takes for the red light to be emitted. This time is measured and correlated to the oxygen concentration. Between the flashes of blue light, a red LED is flashed on the sensor and used as an internal reference.

b) Dissolved oxygen sensors, which are based on the galvanic cell system utilising a membrane to separate the electrolyte and electrodes from the medium, will not be acceptable.

8.1.3 Construction

a) A probe utilising anodes and cathodes shall not be used. Probes shall not make use of a continuously cleansing system, which makes use of a rotating, spring loaded and isolated grindstone.

b) Rather probe making use of luminescent material shall be used.

c) A polystyrene coating on the sensor shall protect the sensor from sunlight.

d) The probe shall be suitable for measurements of dissolved oxygen in an aeration basin, where the linear velocity of the medium may vary between 0 and >1 m/s.

e) The construction of the probe shall be such that there is a continuous circulation of the medium past the electrodes. More than 98 % of the volume of medium surrounding the electrodes shall be displaced in less than 2 minutes.

f) The dissolved oxygen shall be suitable to measure the dissolved oxygen level up to 5 m below the surface of the medium.

8.1.4 Installation requirements

a) The probe shall be factory calibrated before being installed.

b) All equipment mounted outside the instrument enclosure shall be fully weatherproof and suitable for mounting in direct contact with raw sewage and actuated sludge.

c) The dissolved oxygen probe shall be supplied complete with a swivel mounting bracket to position the probe in any position between 0 and 3 m from the mounting wall and to adjust the level of the probe between 0,5 and 5 m below the surface of the medium. The mounting bracket shall be strong enough to accommodate the movement of the medium caused by surface mounted aerators and mixers.

d) A suitable plug in arrangement shall be provided for the probe leads to facilitate removal of the probe for maintenance purposes.

e) Sufficiently long probe leads shall be supplied with the instrument to facilitate the desired installation.

f) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.1.5 Accuracy

The accuracy of the instrument shall be guaranteed equal or better than 0,2 ppm in the range 0-5 ppm and 0,3 ppm in the range 5 - 15 ppm in the actual installation positions.

8.1.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.2 pH Meters

8.2.1 General

The instruments shall be of a type specially developed for application in water treatment plants. It shall be of the in-line type and require negligible maintenance over extended periods.

The meters shall comprise:

a) Measuring unit/detector head/probe

b) Locally mounted control unit/transmitter, with display of current and accumulative flow (in litres per second and kilolitres respectively). The control unit shall generate a 4 – 20 mA signal proportional to the flow reading, suitable for transmission to the remote PLC.

c) A weather proof box with a shield protecting the glass display window from direct sunlight.

d) All mountings, brackets, pedestals etc., required to install the equipment, taking account of the turbulent mixing conditions prevailing at the proposed measuring points

8.2.2 Construction

The transmitter enclosure shall be rated at IP 65.

8.2.3 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed.

c) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

e) All equipment and standards/solutions for calibration of the meters, stored in a sturdy and portable container shall be provided after installation.

8.2.4 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.3 Tubidity Meters

8.3.1 General

The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

The meters shall comprise:

a) Measuring unit/detector head/probe.

b) Control unit/transmitter, with local display of turbidity. The control unit shall generate a 4 - 20 mA signal proportional to the turbidity, suitable for transmission to the remote PLC.

c) Self-priming feed water supply pump with all pipework and isolation valves, to draw sample water from the sampling point, transfer it to the measuring unit and back to the main flow.

d) A self-cleaning system.

e) A weather proof box, in which the measuring and control units are to be installed.

8.3.2 Operating principle

a) Water shall be taken from the main pipe line through a self-priming feed water supply pump, to draw sample water from the sampling point. Water shall be transferred to the measuring unit and back to the main flow system, preferably the filter outlet chamber.

b) The measurement technology shall use infrared pulse scattered light process according DIN EN ISO 7027.

c) The sensor shall continuously measure turbidity in water using detectors at 90 and 180 degrees.

d) The verification of calibration for the sensor shall be by StablCal or dry standard CVM module.

8.3.3 Construction

The transmitter enclosure shall be rated at IP 65.

8.3.4 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed.

c) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.3.5 Accuracy

a) The turbidity meters shall be suitable for measuring the turbidity (in NTU) over a range of 0.0001 to 1000 NTU.

b) The precision shall be ± 0.5 % or ± 0.008 NTU of the measured value.

c) The response time shall be approximately 1 to 60 seconds.

d) The flow rate of sample shall be 0.2 to 1 L/minute.

8.3.6 Maintenance

a) The sensor shall be equipped with a self-cleaning sample chamber that uses a silicon wiper that is held in place magnetically.

b) Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.4 Mass Flow Meters

8.4.1 General

a) The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

b) The meters shall be coriolis type units, suitable for measuring the mass of the specified parameter in the chemical solution over the specified flow range and shall include for density calibration.

The mass flow meters shall comprise:

a) Measuring unit/detector head/probe.

b) Control unit/transmitter, with display of current and accumulative flow (in milligrams per litre and kilolitres respectively). The control unit shall generate three 4 - 20 mA signals proportional to the chemical solution mass flow, density and temperature respectively, each suitable for transmission to a remote PLC (up to 300 m away)".

c) A weather proof box with a shield protecting the glass display window from direct sunlight.

8.4.2 Construction

The transmitter enclosure shall be rated at IP 65.

8.4.3 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed and shall be supplied with official calibration Test Certificates.

c) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

e) Where the diameter of the mass flow meter is not exactly the same as the internal diameter of the pipe in which it is to be installed, the Contractor shall provide suitable length matching diameter pipes on either side of the flow meter, as well as suitable reducers and support brackets.

8.4.4 Accuracy

The precision shall be ± 3 % of the measured mass.

8.4.5 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.5 Residual Chlorine Meters

8.5.1 General

The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

The meters shall comprise:

a) Measuring unit/detector head/probe.

b) Control unit/transmitter, with display of current free chlorine concentration. The control unit shall generate a 4 - 20 mA signal proportional to the concentration, suitable for transmission to the remote PLC.

c) Self-priming feed water supply pump with all pipework and isolation valves, to draw sample water from the sampling point, transfer it to the measuring unit and back to the main flow.

d) A weather proof box, in which the measuring and control units are to be installed.

8.5.2 Operating principle

Water shall be taken from the main pipe line through a self-priming feed water supply pump, to draw sample water from the sampling point. Water shall be transferred to the measuring unit and back to the main flow system.

8.5.3 Construction

The transmitter enclosure shall be rated at IP 65.

8.5.4 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed.

c) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.5.5 Accuracy

The residual chlorine meters shall be suitable for measuring the concentration of free chlorine (in milligrams per litre) over the range of 0.01 to 20 mg/l, to within 3 % of the actual value, in water with a pH of greater than 8.5.

8.5.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.6 Chlorine Leak Detector

8.6.1 General

a) A local display shall indicate the level of chlorine concentration in the area.

b) Audible and visual alarm facilities shall be available at the detector, and the alarm signal must be able to be transmitted to a remote station, if required.

c) The instrument shall be equipped with a test facility to test the alarm operation.

d) The sensor shall be field serviceable.

e) The chlorine detector shall be suitable for the detection of chlorine gas in the atmosphere.

f) The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

The meters shall comprise:

g) Measuring unit/detector head/probe.

h) Control unit/transmitter, with display of current free chlorine concentration. The control unit shall generate a 4 - 20 mA signal proportional to the concentration, suitable for transmission to the remote PLC.

i) A weather proof box, in which the measuring and control units are to be installed.

j) Audible and visual alarm facilities shall be available at the detector, and the alarm signal must be able to be transmitted to a remote station, if required.

k) The instrument shall be equipped with an integral gas generator to automatically test the sensor each day. An alarm shall be sounded should the sensor fail.

l) The design shall be modular to allow single and multi-point detection.

m) The detector shall be supplied with battery back-up for at least 4 hours.

n) A local display shall indicate the level of chlorine concentration in the area.

8.6.2 Operating principle

The sensor shall be sensitive to chlorine gas at levels lower than the OHSACT specify. This level shall typically be in the region of 1 ppm or 3 mg/m³.

8.6.3 Construction

The transmitter enclosure shall be rated at IP 65.

8.6.4 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed.

c) Sufficiently long sensor leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.6.5 Accuracy

The chlorine leak detector shall be suitable for measuring the chlorine in the atmosphere to within 3 % of the actual value.

8.6.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.7 Streaming Current Detector

8.7.1 General

a) A local display shall indicate the ion charge.

b) The sensor shall be field serviceable.

c) The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

The meters shall comprise:

a) Measuring unit/detector head/probe.

b) Control unit/transmitter, with display. The control unit shall generate a 4 - 20 mA signal proportional to the concentration, suitable for transmission to the remote PLC.

c) An electronically controlled drive mechanism

d) A weather proof box, in which the measuring and control units are to be installed.

8.7.2 Operating principle

The SCD analyser detects the electro kinetic charge of a solution to monitor suspended solids and control the addition of flocculants.

8.7.3 Construction

The transmitter enclosure shall be rated at IP 65.

8.7.4 Installation requirements

a) The sample, sourced sufficiently far away from the point at which dosing takes place to permit good mixing, shall preferably be gravity fed to, and drained from, the sample chamber. Where this is not possible, a pump may be used.

b) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

c) The sensor shall be factory calibrated before being installed.

d) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

e) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.7.5 Accuracy

The chlorine leak detector shall be suitable for measuring ion charge within 3 % of the actual value.

8.7.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.8 General

8.8.1 The sample, sourced sufficiently far away from the point at which dosing takes place to permit good mixing, shall preferably be gravity fed to, and drained from, the sample chamber. Where this is not possible, a pump may be used.

9. ANALYSER STATIONS

9.1 General

9.1.1 Where specified, analyser instrumentation shall be grouped together into an analyser station. An analyser station shall consist of the following:

9.1.2 Piping

a) All piping must be 12 mm 316 stainless steel tubing.

b) The tubing shall be secured against the backing plate by means of saddles where applicable.

c) All fittings shall be 316 stainless steel.

d) Bends shall be kept to a minimum.

e) All tubing runs shall be vertical or horizontal

9.1.3 Sample Pot

a) The sample pot shall be 316 stainless steel. The pot shall be of dimensions 150 mm high by 150 mm wide and 150 mm deep.

b) The sample pot shall be installed in such a manner as to allow a beaker to be inserted to take manual samples.

c) The outlet of this sample pot will run to the drain.

d) Water for the sample will be obtained from the outlet of the header pot and will be controlled by means of an isolation valve, ½ inch.

9.1.4 Inlet Manifold

a) The inlet manifold shall be 316 stainless steel.

b) The outlet of the header pot shall be connected to the inlet manifold from the right hand side.

c) The inlet manifold shall have a drain valve at the bottom and piped to the outlet drain.

d) The top of the inlet manifold shall have a ball valve and needle valves for each instrument which will provide a means of isolation and control respectively for the instruments.

9.1.5 Outlet Drain

a) The outlet manifold shall be constructed from 316 stainless steel.

b) The outlets of each analyser will be connected to the outlet manifold with each analyser outlet feeding into a funnel into the outlet manifold.

9.1.6 Analyser Station and Mounting Frame and Backing

a) The analyser shall have 316 stainless steel frame. This frame shall support a 316 stainless steel backing plate.

b) The backing plate shall have a minimum thickness of 2 mm.

c) All the instruments, junction boxes, trunking, supports, brackets etc. shall be mounted on the backing plate.

d) The backing plate shall be drilled and tapped and no nuts are to be used on the back of the backing plate.

e) The entire installation shall be neat and easily accessible to maintenance staff.

f) A 316 stainless steel shelf shall be installed to enable maintenance staff to carry out calibration of instruments. The shelf shall be firmly supported and form part of the installation.

9.1.7 Analyser Enclosure

a) The analyser enclosure shall be rated IP95.

b) The enclosure shall have a minimum thickness of 2 mm.

c) Square key flush mounting locks and 316 stainless steel hinges shall be used.

d) Cable entry shall be from the bottom.

e) All wiring shall be done through grey slotted trunking of adequate size with room for additional wiring if required.

f) 5 Amp circuit breakers shall be provided for the supply to each instrument, for the feed supply pump and for each flow switch.

g) A door interlocked lockable isolator shall be provided.

h) Fused terminals complete with fuses shall be used to isolate the 24 V DC supply to the status contacts of the flow switches.

i) Three 2 position key switches shall be mounted on the door. These shall bear the labels “Maintenance” and “Online” on the front door of the cabinet.

j) When the switch is in the maintenance position (left position) a digital signal shall be sent to the PLC and on the SCADA shall be indicated that the instrument is in “maintenance”.

k) A fused terminal will isolate the power to the key switches mounted on the door.

9.1.8 Flow Switches

a) The outlet of each instrument and the overflow from the header pot shall be provided with a flow switch.

b) The flow switches shall be 24 V DC and have 1 potential free changeover contact.

c) Each flow switch shall be housed in its own junction box inside the analyser station.

d) The junction box shall contain a DIN rail with terminal blocks to terminate a four pair cable plus earth. The first pair will carry the 24 V DC supply to the flow switch.

e) Terminal blocks shall have end stops on both ends.

10. WEIGHING INSTRUMENTS

10.1 Load Cells

10.1.1 The following is applicable to the installation of Load Cells:

a) Load cells shall make use of the strain-gauge principle unless otherwise specified.

b) The mechanical design of the installation shall be designed to minimize horizontal forces.

c) Load cells shall be connected in parallel and correctly shimmed to ensure equal load distribution.

d) A Three cell configurations shall be preferred if practical.

e) Special consideration shall be given protection against electrical noise and lightning.

f) The earthing requirements of the Manufacturer shall be followed.

g) Load cells shall be sealed air-tight and the terminal boxes shall offer protection to IP65.

h) Temperature compensation shall be incorporated.

11. TEMPERATURE

11.1 Temperature meters

11.1.1 General

The instruments shall be suitable for measuring temperature in containers and pipes. The temperature probes shall be suitable for use in hazardous areas (methane gas environment).

11.1.2 Operating principle

The temperature probes shall be of the RTD type complete with a suitable temperature transmitter.

11.1.3 Construction

a) The temperature transmitter shall be of the basic four wire type, with a separate 230 V AC supply and a galvanically isolated 4-20 mA output signal linearly proportional to the measured temperature.

b) The temperature transmitter shall be equipped with a digital local temperature indicator.

11.1.4 Installation

a) Where temperature is to be measured in large containers, e.g. digesters, thermometer pockets will be provided by others.

b) Where the temperature is to be measured in a pipe, a suitable thermowell shall be installed in the pipe to accommodate the temperature probe.

11.1.5 Accuracy

The accuracy of the temperature measurement shall be better than 1 % of full scale deflection.

11.2 Thermocouples

11.2.1 Thermocouples shall be:

a) Chromel-alumel (ISA Type K) for temperatures between -70 ºC and +900 ºC.

b) Platinum / 10 % rhodium platinum (ISA Type S) for temperatures in excess of 900 ºC.

11.2.2 All thermocouples shall be made from premium grade thermocouple wire.

11.2.3 Only thermocouples which are not grounded to the sheath shall be used.

11.2.4 Only duplex or triplex type thermocouples shall be used.

11.2.5 Thermocouple terminal heads shall provide the degree of protection against dust and moisture of IP 65. The heads shall be made of aluminium alloy.

11.3 Resistance temperature detectors

11.3.1 Three wire resistance temperature detectors (RTD) shall be used in applications where thermocouple performance can be influenced by electrical fields.

11.3.2 The choice between the use of thermocouples or RTF shall be based on the suitability for the application.

11.3.3 The choice for using RTD elements (100 Ω @ 0 ºC) shall be limited to temperatures of -175 ºC to +475 ºC. A duplex RTD platinum element shall have sealed windings within high purity alumina insulation with three leads per winding. The element shall be enclosed in a Type 316 stainless steel tube 6,3mm OD.

11.4 Temperature signal transmitters

11.4.1 The temperature signal to console mounted temperature instruments shall be converted to the standard analogue signal (4-20 mA). The following shall apply when temperature transmitters are used:

a) Cold junction compensation shall be done at the transmitter.

b) Radio frequency interference (R.F.I) protection shall be provided.

c) The output-signal shall be linear with respect to temperature.

d) Line resistant shall not affect signal accuracy.

e) The direction in which the transducer output must fail on element failure shall be specified.

11.5 Local temperature indicators

11.5.1 All local temperature indicators shall be adjustable angle, bimetallic actuated, 130 mm diameter dial thermometers with 6,3 mm OD stems. These shall not be installed more than 4 500 mm above grade or a platform. Installations above this height limit shall use remote reading gas or liquid filled thermal system thermometers with a 115 mm diameter indicator installed 1 700 mm above grade or on a platform.

12. INSTRUMENT FIELD WIRING SYSTEMS

12.1 General requirements

12.1.1 All wiring on instrument systems in hazardous areas shall meet the requirements of SANS 10108.

12.1.2 Shielded cable shall be used for all instrument signals of 90 V or less.

12.1.3 Shield and/or shield drain wires for individual pairs and inner overall shields of multi-pair cables shall have continuity from the sensing element to the control room or local panel. The shield on individual pairs shall be carried as an additional wire, isolated from earth with sleeving, wired through separate terminals, and connected to the high quality earth at the control room or panel only. The outer overall shield of multi-pair cables shall be connected to safety earth at the source end only.

12.1.4 Instrument wiring in control rooms shall generally consist of PVC insulated cables installed in trunking or tray, or bunched in control panels.

12.1.5 Field cables shall generally be one continuous run from service to destination but where junction boxes are required they shall enter and exit by the bottom gland plate.

12.1.6 Where instruments are installed in close proximity, instrumentation cables shall be reticulated to an instrumentation junction box, from where one multicore cable will be used to relay the various signals to the PLC.

12.1.7 Where possible, two sensors shall be wired to one transmitter.

12.1.8 Instrumentation cabling shall be run in wireways such as conduit and trunking. No open or loosely hanging instrumentation cables shall be allowed.

12.2 Wiring from instrument to junction box

12.2.1 All field mounted instruments shall be provided with single pair or triple cable installed on rigid supports providing protection against mechanical damage.

12.2.2 All wiring shall meet the electrical area classification requirements of the plant in which it is installed.

12.2.3 No splices shall be made in single pair or triple cables.

12.2.4 Stranded wires shall be connected to terminals with insulated pressure type lugs and each wire shall be marked at both ends with yellow fluorescent label material to indicate the terminal numbers.

12.3 Junction boxes

12.3.1 Field mounted junction boxes shall be provided for the termination of the single pair (or triple) cables and connection to multi-pair cables.

12.3.2 Only one multi-pair cable shall be allowed per junction box.

12.3.3 Junction boxes for outdoor use in non-hazardous areas, or for intrinsically safe systems in hazardous areas, shall be impact and corrosion resistant polyester boxes with terminal blocks and shall have hinged covers. All hinges and cover fasteners shall be corrosion resistant.

12.3.4 Explosion proof junction boxes shall have explosion proof combined breather and drain fittings at the bottom.

12.3.5 All cable runs shall enter junction boxes at the bottom or at the side within 200 mm from the bottom.

12.3.6 Cables between any junction box and control room shall be armoured multicore cables and can be routed above or below ground.

12.3.7 Each junction box shall be numbered and identified with a permanent nameplate.

12.3.8 Separate junction boxes and home run cables shall be provided for each voltage level and signal function.

12.3.9 Terminal blocks shall be sectional (barrier), two screw type for use with pre-insulated tip terminals, or screwless terminal blocks with cage clamp springs for all types of conductors used without terminal lugs.

12.3.10 Minimum spacing in junction boxes shall be 150 mm from terminal block to the side of the box and 150 mm between terminal block centrelines.

12.3.11 All junction points shall be permanently identified, both on the wire and on the terminal block. All terminals within a junction box shall be numbered consecutively. All field cables shall be tagged with the field instrument tag number and shall carry this number continuously to the control room.

12.3.12 All junction boxes shall have sufficient terminal blocks to terminate all cable pairs or triples including shield wire and spares.

12.4 Cable trays

12.4.1 Instrument cables where practicable shall be routed on separate trays from electrical power cables. Particular consideration shall be given to the requirement of specialist cables involving limits on resistance, capacitance and inductance, intrinsically safe electronic circuits and thermocouples.

12.4.2 The Contractor shall generally use existing cable trays, trenches or ducts showing particular consideration for cable types and their segregation requirements.

12.4.3 Vertically oriented cable trays are preferred to minimise fire hazards due to the accumulation of combustible dirt.

12.4.4 Cable trays containing 230 V AC power cables and cable racks containing instrument signal cables and thermocouple cable crossing each other, shall be separated by 100 mm.

12.5 Home run cables

12.5.1 Cabling between the field mounted junction boxes and the control rooms shall be multi-pair cables in overhead cable tray. Instrument leads and thermocouple leads shall not be run in the same multi-pair cable.

12.5.2 Instrument and thermocouple cables shall be isolated from power wiring according to the following directive:

a) In cable racks 230 V AC power cables shall be spaced 100 mm from instrument signal cables and thermocouple cables. In cases where 100 mm spacing cannot be achieved, a metal barrier fixed to the cable rack shall be installed between the 230 V AC power cables and instrument signal/thermocouple cables.

b) If it is required to join two cables on very long runs (more than 1 000m) the cables shall be brought to a connection box and connected through terminal blocks.

c) Multi-pair cables for instruments and thermocouples may be installed in the same tray or duct. Intrinsically safe cables may be installed in the same trays with other instrument and thermocouple cables.

12.5.3 When selecting a new multi-core cable on a project, one with the least standard number of cores possible shall be used. However, if the number of cores to be used exceeds 80 % of the capacity of the cable, then the next larger standard size shall be selected.

12.6 Fire protection of cables

12.6.1 Fire protection shall be provided for all power and signal cables in emergency service to afford a fire rating of half an hour life in the event of fire in process areas where fire hazards exist.

12.6.2 General process control and power cables not requiring fire protection, shall be segregated from the critical cables if there are economic benefits in having these categories of cable kept separate.

12.6.3 The preferred method of protection is direct burial of the cable to a point vertically below the emergency valve. The above ground cable shall be fire protected to afford half an hour life.

12.6.4 In the case where emergency valves are clustered sufficiently close together to justify the use of multi-core cable for the "home-run", a fire protected junction box shall be installed directly above grade. Field cable runs from the emergency valves to the junction box shall be fire resistant cable or be fire protected.

12.6.5 Should direct burial of emergency service cables prove impractical, above ground cables and cable trays with fire protection shall be installed.

12.6.6 Care shall be taken with regards to the insulation of cables buried in areas where spillage or gradual build-up of chemical products in the ground may occur.

12.6.7 Spare capacity in buried multi-core control cables shall be 33 %.

12.7 Interconnections

12.7.1 All materials required to interconnect or install instrument or electrical devices located on the package unit shall be supplied as part of the package (e.g. thermowells for thermocouples).

12.7.2 All interconnections between items supplied in the package unit (electrical, pneumatic, etc.) shall be supplied and installed by the Contractor.

12.7.3 All devices shall be pre-wired to a junction box, pre-piped, etc., except where shipping constraints necessitate dismantling of the unit, in which case interconnecting cables, pipe, tubing, etc., shall be clearly tagged for re-connection at the site.

12.7.4 Erection and assembly, and testing instructions shall be provided for and shall accompany any disassembled instrumentation or electrical equipment.

12.8 Instrument Signal Levels

12.8.1 Control voltage shall be 24 V DC for field device circuits and programmable controller inputs and outputs.

12.8.2 Signals to all programmable controller inputs shall be from isolated, voltage-free contacts capable of reliably switching 2A at 24 V DC.

12.8.3 The Contractor shall supply analogue instruments whenever possible with 4-20 mA signals.

12.8.4 All relay contacts shall be capable of reliably switching 2 A at 230 V AC and 24 V DC. Contacts shall be self-cleaning (wiping) action or be hermetically sealed. Where interposing relays are used the relay coil shall be rated for continuous operation.

12.8.5 Preference shall be given to loop-powered instruments wherever possible.

12.8.6 Four-wire instruments shall provide isolated signals where possible or shall incorporate a signal-isolating device.

12.8.7 Control system analogue inputs and outputs shall be isolated mA signals unless otherwise specified or agreed. Voltage inputs or outputs are generally not acceptable.

12.8.8 Any transducers required for signal conditioning and measuring devices with analogue outputs shall be smart loop powered devices with 4-20 mA outputs.

12.8.9 Low level (mV) signals shall be converted to 4-20 mA signals as close to the source as possible for field transmission (e.g. thermocouple).

12.8.10 Intelligent instruments (e.g. analysers) may communicate directly to a PLC utilising a communication bus protocol.

12.8.11 In summary, signal levels shall be used as listed in below:

Table 2: Signal Level Usage

Application	Signal Level
Analogue signals	4-20 mA (24 V DC)
Alarm Signals	24 V DC
Counters	24 V DC
Solenoid Valves	24 V DC
On-Off controls	24V DC
Status signals	24 V DC
Local pneumatic control	20 – 100 kPa (g)

13. PROCESS CONNECTION LOCATIONS

13.1 General

13.1.1 Instrument process connections shall be located for maximum convenience in operation and servicing of the instruments. The following general rules shall be adhered to, unless limited by other requirements in the design of a unit.

13.1.2 The location for installation of equipment shall be agreed on site with the Engineer, and shall be positioned not to restrict effective maintenance. Sensor cable joints shall be kept to minimum and where possible the length shall be continuous from sensor to transmitter.

13.2 Orientation of connections

13.2.1 Connections shall be oriented so that instruments or piping shall not obstruct aisles, platforms or ladders.

13.3 Field mounted transmitters

13.3.1 All field mounted transmitters shall be installed so that they are accessible from grade, platform or permanent ladders.

13.4 Control valves

13.4.1 Control valves shall be accessible from grade or platforms. A minimum of 250 mm shall be allowed between the top of the valve actuator and the underside of the nearest obstruction above it to permit the removal of internal parts. A minimum of 150 mm shall be allowed between the bottom side of valves and grade of platforms if the valve requires bottom access for maintenance.

13.5 Clearance for adjacent equipment

13.5.1 Clearance shall be provided at flow meter offices for valves or other components that may be located adjacent to the line.

13.6 Vessel connections

13.6.1 Connections on vessels for gauge glasses and level instruments shall be oriented to minimise the effect of inlet and outlet streams of the instruments.

13.7 Instrument accessibility

13.7.1 All instruments requiring adjustment shall be accessible for servicing from grade, walkways, permanent ladders, or platforms.

13.7.2 Flow meter primary devices, thermal system bulbs and thermocouples shall be accessible from walkways, permanent ladders, platforms or grade.

13.8 Instrument orientation

13.8.1 Instruments shall face the operating area so that the response to process adjustments can be observed from the operating area.

13.8.2 All instruments installed outdoors shall be installed so that the display faces south if practical.

14. DRAWINGS AND DOCUMENTATION

14.1 Drawings and design documentation

14.1.1 All drawings, information, and documentation shall be in the English language, and each item shall be identified with the Employer's name and project / scheme / contract reference title and numbers, the Employer's representative's name and reference numbers, and the Manufacturer's works / contract / order references. Drawings for acceptance shall be provided on A3 paper copies.

14.1.2 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied.

14.1.3 Manual formats shall be A4 size on the filing side which shall be vertical with 20 mm margin for filing.

14.2 Drawings and Documentation for Approval by the Engineer

14.2.1 The following documentation and drawings shall be submitted to the Engineer:

a) Prior to procurement

b) Detailed instrumentation list including tag number, supplier, ranges, location, signal, error signal and surge protection

c) General arrangement of instrumentation and control enclosures and junction boxes

d) Prior to installation

e) Hook-up and loop drawings

14.3 Operating & Maintenance Manual

14.3.1 The operating manuals shall include at least the following:

a) Manufacturer's name, address, telephone number and telefax numbers

b) A full technical specification of the equipment.

c) Full description and details of design capacity and design criteria for each item of equipment and each product

d) Detailed description of the function of all operator controls

e) Detailed description of all alarms, indications and protective devices

f) Detailed description of all adjustments

g) Operating instructions. These shall cover the different modes of operation and start-up/shut-down procedures

h) Relevant reduced drawings - general arrangements, assemblies, electrical schematics and parts lists

i) Procedures in case of a fault

j) Technical description of all components (Instrument Specification Sheets)

k) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures

l) Recommended inspections and frequency thereof

m) Schedules for running and shutdown maintenance

n) Spare parts information incorporating cross-section/"exploded" view drawings/illustrations with parts references/descriptions which provide clear reference to the Manufacturers part number and original manufacturer's name and part number when applicable.

o) All Process Equipment alarm and control parameters e.g. trip amp settings, control set points and control action values etc.

14.4 Certification

14.4.1 The testing results and certification shall include at least the following:

a) Suppliers acknowledgement of purchase order

b) Certification copies e.g. hazardous area classification

c) Pre-installation check sheets / Factory test certificate

d) Loop testing sheets

e) Acceptance certificate

f) Calibration test certificates

g) All "as built" design documentation

14.4.2 The Contractor shall guarantee that all products shall be suitable for the intended application and shall be capable of the duties specified.

14.4.3 The period for which the Contractor shall maintain the works in a perfect state of repair, order and condition shall be 12 months from the issue of the total plant taking-over certificate.

15. INSPECTION, TESTING AND CALIBRATION

15.1 General requirements for testing

15.1.1 Manufacturers that supply field instruments shall factory test and pre-assemble, fit accessories, tag, configure, calibrate and shop function test (including 24 hour burn in) instruments prior to delivery.

15.1.2 The Contractor shall be responsible for the commissioning of all services and equipment supplied and installed under the Contract. He shall provide proof of conformance and Manufacturer's performance guarantees for the relevant equipment.

15.1.3 All work, activities, instrument serial numbers, adjustments, commissioning results, names of personnel, dates, times etc. shall be scheduled in an approved format throughout the duration of the works. The Contractor shall ensure that any system which he intends to operate is in a safe and ready condition.

15.1.4 The Engineer reserves the right to witness all or part of the works factory acceptance tests. At least 48 hours' notice shall be given to the Engineer of any test. The accuracy of the test instruments and methods shall be demonstrated to the Engineer when required. The Contractor shall make available to the Engineer, copies of the relevant test sheets, prior to witnessing.

15.1.5 Official factory test/calibration certificates of all instrumentation shall be provided to the Engineer and included in the Operation and Maintenance Manual. Full factory traceability shall be available on request.

15.1.6 Any damage to plant or equipment during commissioning by the tests shall be rectified by the Contractor.

15.1.7 Any defects cause by poor workmanship, materials and performance maladjustments or other irregularities which become apparent during the testing and commissioning operations shall be rectified by the Contractor at his expense and the tests shall be repeated at the Contractor's expense to the satisfaction of the Engineer.

15.1.8 The Contractor shall ensure that all necessary spares are available on site during commissioning.

15.1.9 Four copies of final test results shall be issued to the Engineer in an appropriate and approved format

15.1.10 Instrument data sheets are to be 'as built' and material plus test (pressure, leak, hazardous area) certificates and calibration sheets are to be provided for each instrument in accordance with the data sheets.

15.1.11 The equipment shall be tested and commissioned together with the relevant pipework and other equipment such as pumps or compressors.

15.1.12 Prior to shipment the following shall be confirmed:

a) Standard manufacturer calibration and alignment tests of all instruments have been completed.

b) A parameter printout for electronic instrumentation is attached to the instrument calibration sheet.

15.1.13 Key non-standard set-up parameters shall be noted on the instrument data sheet.

15.1.14 A calibration sticker shall be placed on all shop tested and calibrated instruments.

15.1.15 The Contractor shall be responsible for all instrument calibration on site if the instrument requires adjustment or further calibration.

15.1.16 All cables shall be insulation and continuity tested before being connected at either end.

15.1.17 Wherever possible instrumentation once installed shall be fully checked and tested in service and test sheets completed.

15.1.18 After completion of installation, the Contractor shall provide evidence of the satisfactory operation of all equipment before the site acceptance certification be validated.

15.2 Visual checks

15.2.1 The Contractor shall carry out the following visual inspections to ensure that:

a) Terminals, cables, tubes, piping instruments and equipment have been identified and labelled.

b) Painting and protection against corrosion is complete.

c) Correct materials have been used.

d) Reticulation piping and equipment is adequately supported and accessible.

e) Installations are in accordance with the contract documents.

f) All connections are taped and tight.

g) All air supplies to instruments are on and pressure regulators are set correctly.

h) Impulse lines and air supply lines are leak tested. All pipe and tubing runs shall be pressure tested using air at 700 kPa and tested for leaks.

i) Particular attention is to be paid to the inspection of earthing to ensure that all equipment manufacturers' requirements are met.

j) Air lines are to be blown out with dry, filtered air before being connected to field devices

k) All cables tied in cable tray or installed in approved conduit.

15.3 Static tests - Instrument air supply lines

15.3.1 The following test shall be carried out:

a) Where possible, the line shall be disconnected at the instrument and blown through via the main instrument air supply. The line shall be reconnected and pressurised via the main instrument air supply and soap tested.

b) If it is not possible to use main instrument air to pressurise the line (i.e. downstream of a solenoid valve), bottled gas shall be used for the test in lieu of main instrument air.

c) If the pressure test will cause actuation of a final element the line shall not be reconnected after blow through. It shall be plugged and pressure tested.

d) The tested line shall be marked to indicate that it has been blown through and pressure tested. If main instrument air is used for these tests it shall be turned off when the test is completed.

15.4 Functional tests

15.4.1 Functional testing shall be conducted to confirm all equipment operates as per the Control Philosophy and the Test Sheets.

15.4.2 The Contractor will provide a Test Sheet for every loop. This sheet will show the tag number, instrument range, process signal spans, alarm settings, etc. for the instruments.

15.4.3 By performing functional tests the Contractor will show and record that all instrumentation when signalled, or excited performs the dynamical functions for which it was designed, and that all complete loops and all interconnections are correct.

15.4.4 The Contractor shall ensure that all field instruments and all control room instruments, or SCADA display belonging in the same loop, are functionally tested at the same time to prove the whole loop is correct.

15.5 Field Instruments

15.5.1 For transmitting instruments, a simulated process input of 0, 25, 50, 75 and 100 % both rising and falling shall be injected into the transmitter.

15.5.2 The transmitter shall be powered by the respective instrument power. The reading shall be noted for each input, and checked on the control System SCADA displays.

15.5.3 If a local indicator (4-20 mA) is in series with the transmitter, its reading shall also be recorded for each input. The transmitter and local indicator shall be adjusted if necessary until the output is within specification.

15.5.4 For receiving instruments, signals of 4 mA, 8 mA, 12 mA, 16 mA and 20 mA both rising and falling shall be injected via the control system. The output of the receiving instrument shall be adjusted if necessary until it is within specification.

15.5.5 Permission must be obtained prior to testing final elements. The final element shall be stroked open to close and the position noted for 0, 50 and 100 % signals. If main instrument air is used for these tests, it shall be turned off after the test is completed.

15.5.6 For switching instruments a simulated process input or mechanical actuation shall be applied and the alarm initiated. The switch shall be adjusted if necessary so that it operates at the correct setting, e.g.

a) Pressure switch: apply pressure equal to the set point

b) Flow switch: apply liquid flow equal to the set point

c) Level transmitter with alarm contact: raise the level to the set point

15.5.7 Switching valves shall be stroked open to close by energising and de-energising the respective solenoid valve. The results shall be recorded on the test sheet. Permission shall be obtained prior to testing switching valves.

15.5.8 For temperature signals the cable shall be disconnected and a resistance or mV signal shall be injected direct to the cable. All temperature sensors shall be checked for open or short circuit.

15.5.9 For magnetic type level gauges the float in the tube shall be moved up and down. The indication shall be checked for all possible positions.

15.5.10 All in line pressure instruments shall be subjected to non-destructive testing to the applicable piping code or vessel specification, including the following as a minimum in the absence of any other guide:

a) Pressure tests to 1.5 times the system design pressure at design temperature.

b) Radiographic testing of welds to detect all flaws (by a qualified operator).

15.5.11 In line instruments and control valves must be replaced by spools while process lines are cleaned and tested.

15.5.12 Thermocouple inputs shall be tested for correct burn out / open circuit response and indication. Unless otherwise specified, temperature transmitters shall be configured for upscale burnout.

15.6 Control Components

15.6.1 Where the package has no integral control system or control panel there shall be a complete test of all instrumentation from the point of interface (e.g. junction box for external connection).

15.6.2 All control valves shall be stroked without the positioner fitted to confirm bench set range and after the positioner is fitted to test the action of analogue and digital feedback signals.

15.6.3 Control valves and actuators are to be stroked over their entire range and feedback checks performed at 0, 25, 50 75 and 100 % of travel. Hysteresis checks are to be performed to ensure that process control requirements are met.

15.6.4 Function generators are to be used to test all inputs at the field end of input cables. i.e. mV, mA etc. At least three input signals shall be used. These are 0 %, 50 % and 100 % of range.

15.6.5 Control loops shall be tested to confirm control action and to ensure that the dynamic response is suitable for the process being controlled.

15.6.6 All sequence logic is to be tested to ensure correct operation of the process and to ensure that a malfunction at any time in the sequence shall not leave plant, equipment or personnel exposed to unsafe conditions.

15.6.7 All devices shall be tested to ensure that indications and alarms function correctly.

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