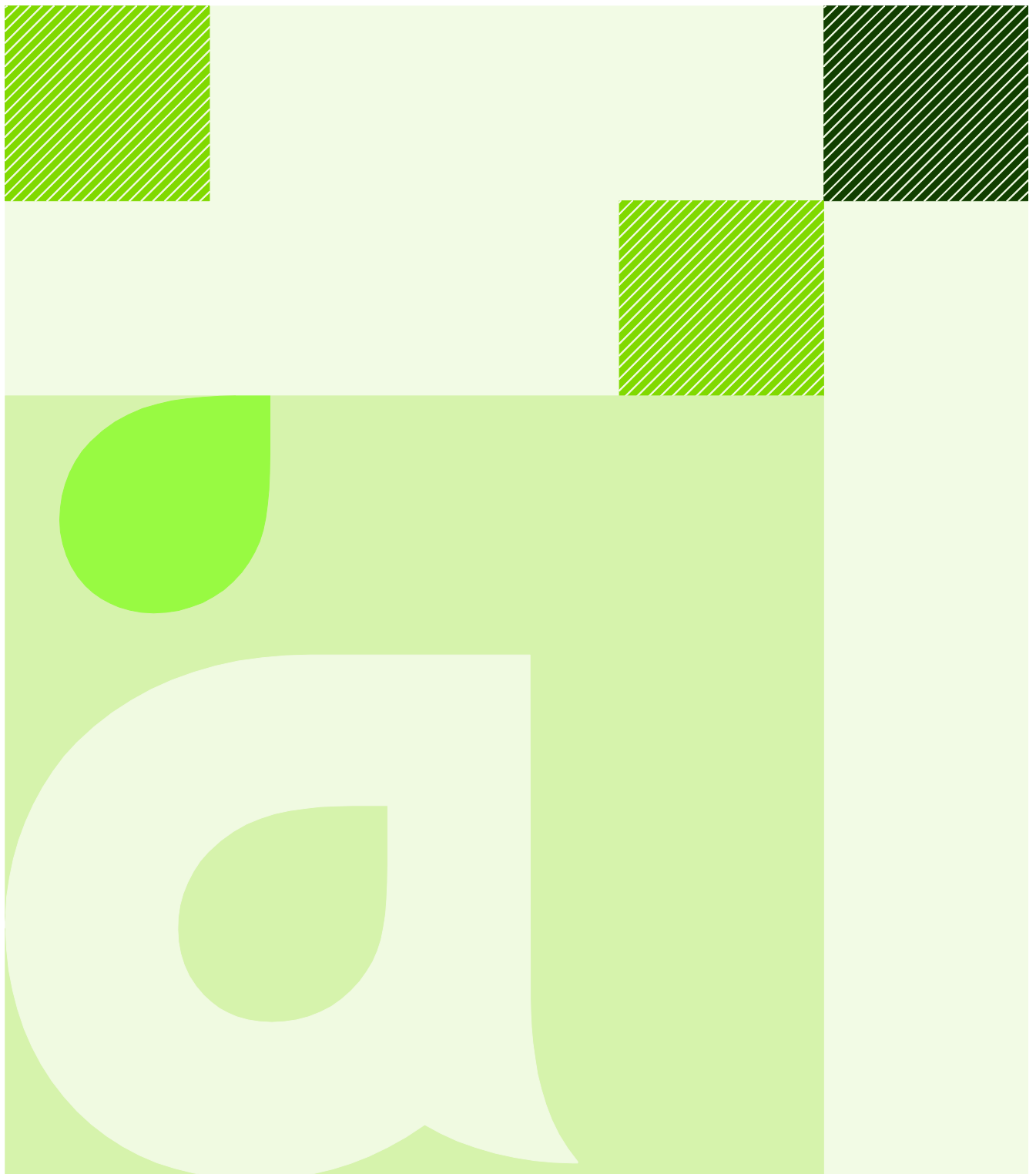




Engineering Specification

Fire Detection and Alarm System
(FDAS) Installations

18 August 2016

Revision: 0

Reference: EL-0001

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

- Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
- Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control							aurecon
Specification title		Fire Detection and Alarm System (FDAS) Installations					
Document ID			Reference number		EL-0001		
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\AURECON STANDARD SPECS\WORKING\E_Building Electronics					
Rev	Date	Revision details/status	Prepared by	Author	Verifier	Approver	
0	18 August 2016	Updated to include 1 st review comments	K. Adu-Asomaning	K. Adu-Asomaning	C. Reeder	G. Gous	
Current revision		0					

Approval			
Author signature		Approver signature	
Name	Kwame Adu-Asomaning	Name	G. Gous
Title	Electrical Engineer	Title	Associate (Pr. Eng)

Contents

1. SCOPE	1
1.1 Application	1
1.2 General	1
1.3 System Architecture	1
1.4 System Characteristics	1
2. STANDARDS	3
2.1 Associated Documentation	3
2.2 Regulations, Specifications and Standards	3
3. COMPONENTS AND EQUIPMENT	5
3.1 General	5
3.2 Fire Detection Control Panel	5
3.3 Power Supply	6
3.4 Detectors	6
3.5 Manual Call Points	8
3.6 Isolators	8
3.7 Input/Output Units	8
3.8 Annunciation Devices	9
3.9 Remote Link	10
3.10 Software Package	10
3.11 Cabling	10
4. INSTALLATION OF COMPONENTS AND EQUIPMENT	12
4.1 General	12
4.2 Cables	12
5. DRAWINGS AND DOCUMENTATION	14
5.1 Generals	14
5.2 Drawings	14
5.3 Mimic Panels	14
5.4 Operating and Maintenance Manual	14
6. TESTING AND COMMISSIONING	16
6.1 General	16
6.2 Testing and Commissioning	16

Tables

Table 1 Standards	4
Table 2 Mounting Heights	12

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.

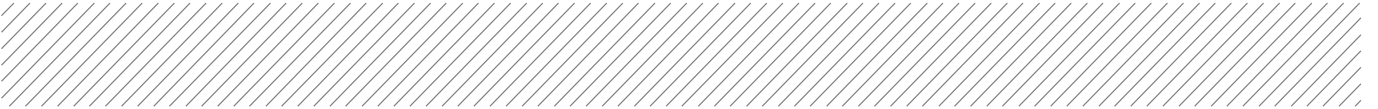
Refer to the Project Specification for the applicable standard to use for the specific project either South African National Standards (SANS) or British Standards (BS).

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 mm² 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

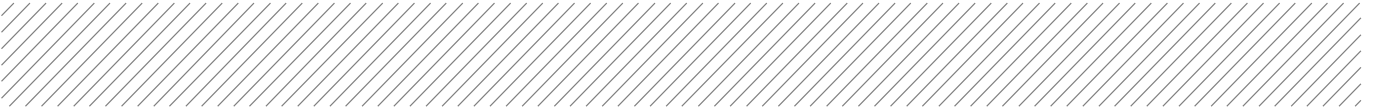
3.10.1 Monitoring and configuration software package

- 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 while 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.

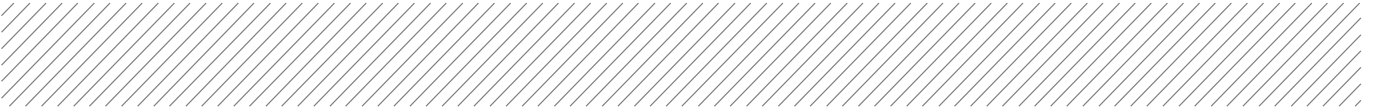
6. TESTING AND COMMISSIONING

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.



Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre

1 Century City Drive

Waterford Precinct

Century City

Cape Town

7441

PO Box 494

Cape Town

8000

South Africa

T +27 21 526 9400

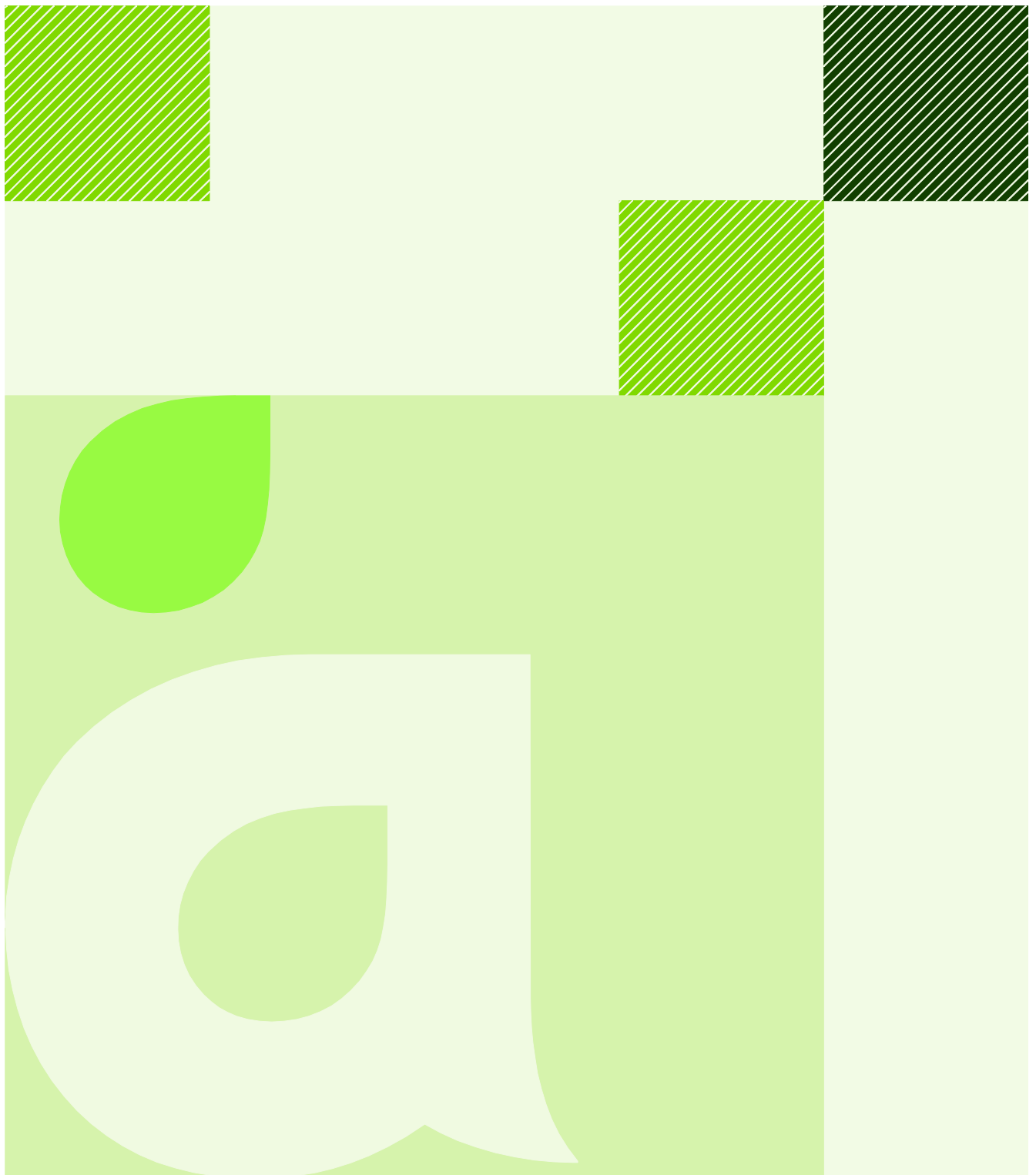
F +27 21 526 9500

E capetown@aurecongroup.com

W aurecongroup.com

Aurecon offices are located in:

Angola, Australia, Botswana, Chile, China,
Ethiopia, Ghana, Hong Kong, Indonesia,
Lesotho, Libya, Malawi, Mozambique,
Namibia, New Zealand, Nigeria,
Philippines, Qatar, Singapore, South Africa,
Swaziland, Tanzania, Thailand, Uganda,
United Arab Emirates, and Vietnam.



Engineering Standard

General Electronic Installations

25 June 2015

Revision: 0

Reference II-0001

Document control record

Document prepared by:

Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400

F +27 21 526 9500

E capetown@aurecongroup.com

W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

- a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
- b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control					aurecon	
Specification title		General Electronic Installations				
Document ID		II-0001	Reference number		II-0001	
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINALWORD				
Rev	Date	Revision details/status	Prepared by	Author	Verifier	Approver
0	25 June 2015	First issue	M Kriel	K O'Kennedy	A Schröder	O Fair
Current revision		0				

Approval			
Author signature		Approver signature	
Name	Kenney O'Kennedy	Name	Owen Fair
Title	Electrical Engineer	Title	Technical Director

Contents

1. SCOPE	1
1.1 Application	1
1.2 General Requirements	1
2. STANDARDS	2
2.1 Associated Documentation	2
2.2 Statutory Requirements	2
2.3 Reference Standards	2
3. CONSTRUCTION REQUIREMENTS OF ELECTRONIC ASSEMBLIES	3
3.1 General	3
3.2 Enclosures	3
3.3 Construction	3
4. INTERNAL WIRING AND FIELD CONNECTIONS	5
4.1 General	5
4.2 Wire ways inside Assembly	5
4.3 Gland Plates	6
4.4 Identification	6
4.5 Termination	6
4.6 Junction Boxes	7
5. EARTHING	8
5.1 General	8
5.2 Earth Bars	8
5.3 Earth Electrode	9
5.4 Earthing of Communication and Signal Cables	9
6. LIGHTNING AND SURGE PROTECTION	11
6.1 General	11
6.2 Earthing for Lightning and Surge Protection	11
6.3 Surge Protection	12
7. SIGNS AND LABELS	15
7.1 General	15
7.2 Safety Signs	15
7.3 Labelling	16
8. INSTALLATION REQUIREMENTS	18
8.1 Shipping	18
8.2 Transportation and installation	18

9. FUNCTIONAL DESIGN	19
9.1 The Project Specification	19
9.2 Motor and Instrumentation Table	19
9.3 I/O List	19
9.4 Technical Detail Sheets	19
9.5 Control Philosophy	19
9.6 Cable Block Diagram	19
9.7 Assembly general arrangement drawing	19
9.8 Building arrangement and equipment location drawing	19
9.9 Contractor's Design	19
10. TESTING AND COMMISSIONING	20
10.1 General requirements for testing	20
10.2 Factory acceptance tests (FATs)	20
10.3 Site acceptance test (SAT)	21
10.4 Commissioning and other tests	21
11. DOCUMENTATION AND TRAINING	22
11.1 General	22
11.2 Drawings for Approval by the Engineer	22
11.3 Testing Documentation and Reports	22
11.4 Operating and Maintenance Manual	23
11.5 Training	24
11.6 Operations& Maintenance training sessions	25

Tables

Table 1 Reference Standards	2
Table 2 Minimum levels of ingress protection	3

[Copyright 2015 Aurecon South Africa (Pty) Ltd. All rights reserved.

The contents of this Document are both privileged and confidential and may not be disclosed or reproduced, except as expressly permitted in writing by Aurecon South Africa (Pty) Ltd. All requests should be sent to the attention of the Legal Department, Aurecon South Africa (Pty) Ltd, PO Box 74381, Lynnwood Ridge, 0040. In this regard the attention of every reader or recipient of this document is drawn to the provisions of the paragraph, which follows, the contents of which shall be binding on such reader and/or recipient.

Copyright subsists in this Document and all attachments hereto, which shall include all and/or any ideas, plans, models and/or intellectual property contained in this Document. Any unauthorised reproduction, adaptation, alteration, translation, publication, distribution or dissemination of the whole or any part of this Document in any manner, form or medium (including, but not limited to, electronic, oral, aural, visual and tactile media) whatsoever will constitute an infringement of Aurecon's copyright and other intellectual property rights. Aurecon reserves the right to take appropriate legal action in the event of any such unauthorised use.]



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 mm² 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

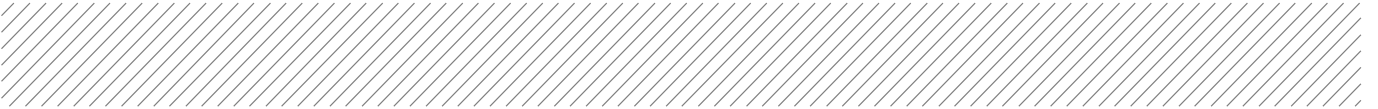
- 6.2.1 The Lightning Protection System (LPS) shall be designed and selected to mitigate the expected lightning intensity on the site and as defined in the Project Specification.
- 6.2.2 Unless stated otherwise in the Project Specification, the Lightning protection system shall be assumed to be existing or installed by others under a separate Contract and the Electronic Assembly lightning 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 lightning 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 lightning 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 mm² for Class II SPD (power) and 1 mm² 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 μ s 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 μ s-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 μ s, 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 μ s. 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 devices (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.



Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400

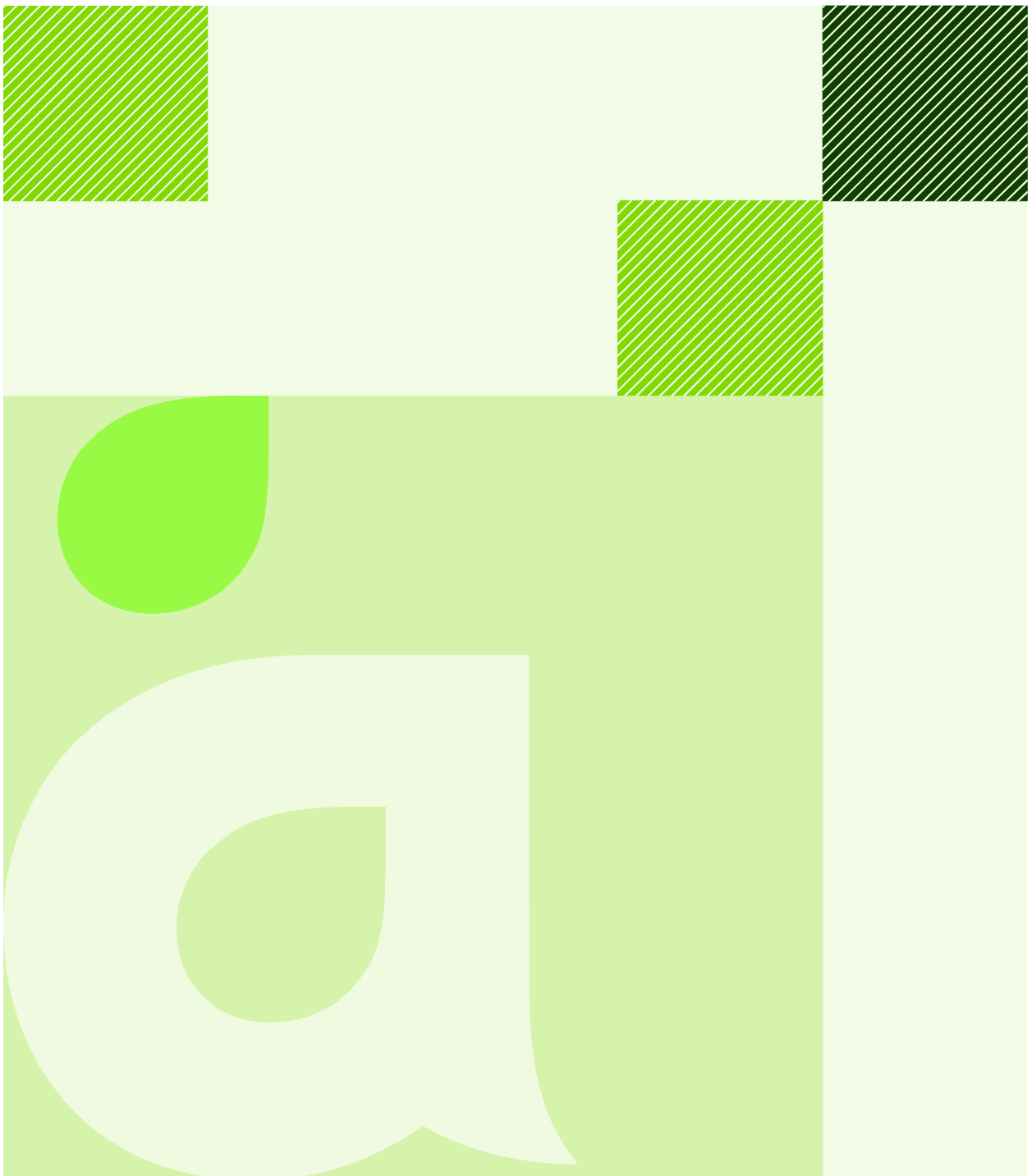
F +27 21 526 9500

E capetown@aurecongroup.com

W aurecongroup.com

Aurecon offices are located in:

Angola, Australia, Botswana, Chile, China,
Ethiopia, Ghana, Hong Kong, Indonesia,
Lesotho, Libya, Malawi, Mozambique,
Namibia, New Zealand, Nigeria,
Philippines, Qatar, Singapore, South Africa,
Swaziland, Tanzania, Thailand, Uganda,
United Arab Emirates, Vietnam.



aurecon

Engineering Standard
Instrumentation

22 November 2016

Revision:1

Reference: II-0007

Document control record

Document prepared by:

Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre

1 Century City Drive

Waterford Precinct

Century City

Cape Town

7441

PO Box 494

Cape Town

8000

South Africa

T +27 21 526 9400

F +27 21 526 9500

E capetown@aurecongroup.com

W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

- Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
- Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control							aurecon
Specification title		Instrumentation					
Document ID		II-0007	Reference number		II-0007		
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	Date	Revision details/status	Prepared by	Author	Verifier	Approver	
0	25 June 2015	First issue	M Kriel	K O'Kennedy	E Biesenbach	O Fair	
1	22 Nov 2016	Various updates	A Schroder	A Schroder	E Biesenbach	O Fair	
Current revision		0					

Approval			
Author signature		Approver signature	
Name		Name	
Title		Title	
Alfred Schroder		Owen Fair	
Associate		Technical Director	

Contents

1. SCOPE	1
1.1 Application	1
1.2 General Requirements	1
1.3 Installation Performance Requirements	1
2. STANDARDS	2
2.1 Associated Documentation	2
2.2 Statutory Requirements	2
2.3 Recognised Standards	2
3. GENERAL INSTALLATION REQUIREMENTS	4
3.1 Overview of Requirements	4
3.2 Environmental Exposure	5
3.3 Units of Measure	6
3.4 Preferred Equipment List	6
3.5 Equipment Numbering	6
3.6 Instrument Tags and Nameplates	7
3.7 Instrument Power Supplies	7
3.8 Process Isolation	7
3.9 Transportation and Shipping	7
4. INSTRUMENT SENSORS	9
4.1 General requirements	9
5. FLOW	10
5.1 General requirements	10
5.2 Orifice plate flow installations	10
5.3 Electromagnetic Flow Meters	10
5.4 Mass Flow Meters	12
5.5 Ultrasonic Open Channel Flow Meters and Level Meters	13
5.6 Ultrasonic Area Velocity Flow Meters	15
5.7 Averaging Pitot Tube Gas Flow Meters	16
5.8 Mechanical Flow Meters	17
5.9 Flow Switches	18
6. LEVEL	19
6.1 General requirements	19
6.2 Ultrasonic and Radar Level Meters	19
6.3 Capacitance Level Transmitter	20
6.4 Hydrostatic Liquid Level Meters	21
6.5 Level Switches	23
7. PRESSURE	24
7.1 General requirements	24



8. TEMPERATURE	26
8.1 Temperature meters	26
8.2 Thermocouples	26
8.3 Resistance temperature detectors	27
8.4 Temperature signal transmitters	27
8.5 Local temperature indicators	27
9. ANALYTICAL INSTRUMENTS	28
9.1 Dissolved Oxygen Meters	28
9.2 pH Meters	29
9.3 Turbidity Meters	30
9.4 Residual Chlorine Meters	31
9.5 Chlorine Leak Detector	32
9.6 Streaming Current Detector	33
9.7 General	34
10. ANALYSER STATIONS	35
10.1 General	35
11. WEIGHING INSTRUMENTS	37
11.1 Load Cells	37
12. PROCESS CONNECTION LOCATIONS	38
12.1 General	38
12.2 Orientation of connections	38
12.3 Field mounted transmitters	38
12.4 Control valves	38
12.5 Clearance for adjacent equipment	38
12.6 Vessel connections	38
12.7 Instrument accessibility	38
12.8 Instrument orientation	38
13. DRAWINGS AND DOCUMENTATION	39
13.1 Drawings and design documentation	39
13.2 Drawings and Documentation for Approval by the Engineer	39
13.3 Operating & Maintenance Manual	39
13.4 Certification	40
14. INSPECTION, TESTING AND CALIBRATION	41
14.1 General requirements for testing	41
14.2 Visual checks	42
14.3 Static tests - Instrument air supply lines	42
14.4 Functional tests	42
14.5 Field Instruments	43
14.6 Control Components	44



Tables

Table 1: Reference Standards

2

[Copyright 2015 Aurecon South Africa (Pty) Ltd. All rights reserved.

The contents of this Document are both privileged and confidential and may not be disclosed or reproduced, except as expressly permitted in writing by Aurecon South Africa (Pty) Ltd. All requests should be sent to the attention of the Legal Department, Aurecon South Africa (Pty) Ltd, PO Box 74381, Lynnwood Ridge, 0040. In this regard the attention of every reader or recipient of this document is drawn to the provisions of the paragraph, which follows, the contents of which shall be binding on such reader and/or recipient.

Copyright subsists in this Document and all attachments hereto, which shall include all and/or any ideas, plans, models and/or intellectual property contained in this Document. Any unauthorised reproduction, adaptation, alteration, translation, publication, distribution or dissemination of the whole or any part of this Document in any manner, form or medium (including, but not limited to, electronic, oral, aural, visual and tactile media) whatsoever will constitute an infringement of Aurecon's copyright and other intellectual property rights. Aurecon reserves the right to take appropriate legal action in the event of any such unauthorised use.]



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:
Provide a fully instrumented and automated process capable of being controlled and monitored from a Central Control Room.
Where specified in the Particular Specifications, implement all control in the on-site 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 Instrumentation Schedule to accomplish the required process monitoring and control.

1.3 Installation Performance Requirements

- 1.3.1 The installation shall be suitable for its intended duty with respect to the electrical supply, measurement principal, and process connection 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) NFPA (National Flame Proof Association) as required in Hazardous Locations
- 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 61643-1	Low-voltage surge protective devices Part 1: Surge protective devices connected to low-voltage power distribution systems - Requirements and tests

SANS Number	Description
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 230 V, 50 Hz alternating power supply OR 24 V direct current power supply and environmental conditions as per project description and general information.
- 3.1.2 The instrument enclosure shall house the instrument transmitter, power supplies and the required EMI/RFI surge suppressors. A local power supply circuit breaker shall be provided in the instrument enclosure to protect and isolate the instrument.
- 3.1.3 All instruments shall be equipped with local indication, indicating the process variable being measured.
- 3.1.4 All analog instruments shall provide an isolated 4-20 mA output proportional to the process variable being measured. Discrete Instruments shall provide a potential free 24V DC contact as far as is practical. Transistor outputs (NPN or PNP) shall only be permitted where there is no potential free contact alternative.
- 3.1.5 All instruments shall be supplied complete with a suitable pedestal for mounting the instrument transmitter with 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 when specified in the particular specification and protected against corrosion related to climatic weather conditions, and/or the location of installation with respect to the process environment.
- 3.1.9 Process Connections shall be stainless steel or HDPE with compression type couplings as called for in the particular specification.
- 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 cables (excluding transducer signal cables) 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 under the contract 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 The installation shall be a highly reliable, safe and efficient system with fault and diagnostic reporting capabilities.

- 
- 3.1.15 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.
- 3.1.16 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.
- 3.1.17 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.
- 3.1.18 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.
- 3.1.19 The transmitter shall be mounted separate from the sensor and shall have local indication where specified in the Particular Specification and Instrumentation Schedule.
- 3.1.20 The Contractor shall supply all the process connections, equipment, fittings, mountings and brackets necessary to install, test and commission all instrument related items covered by this Contract.
- 3.1.21 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.
- 3.1.22 Where openings through walls are provided for the Contractor to install pipe work (such as for example water sampling for 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.
- 3.1.23 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.
- 3.1.24 All mountings, brackets, and pedestals shall be stainless steel where called for in the particular specification, otherwise suitable corrosion protected steel shall be provided as a minimum.

3.2 Environmental Exposure

- 3.2.1 Throughout the construction period, all equipment shall be adequately protected against adverse climatic conditions, site specific corrosive environments and mechanical damage.
- 3.2.2 All instrumentation shall be designed for use in the aggressive environment encountered at the type of treatment works, pump station, mining operation or industrial plant. 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 when required outdoors.

- 
- 3.2.4 All instrument transmitters 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 allow for the supplied equipment to be installed outdoors and exposed to an environment of direct sunlight, rain, dust and exposure to coastal atmospheres, and that the supplied equipment will be subjected to spillage of process liquids, corrosive liquids and splashing from high pressure wash-down water in certain areas of the plant.
 - 3.2.6 Non-metallic weather proof covers shall be UV stabilised long life type.
 - 3.2.7 Sensors / detector heads shall be rated IP 68 for maximum environmental and potential flooding protection.
 - 3.2.8 Instrumentation shall be inherently protected against electromagnetic interference as well as induced surges due to transients in the power supply system or adjacent electrical equipment.

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 metric and expressed in nominal sizes: DN (diameter nominal) - mm.
- 3.3.3 Instrument tube sizing and all associated fittings shall be provided 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 those stated in the Technical Data Sheets.
- 3.4.3 The Contractor shall note that the Engineer reserves the right to modify, increase or reduce the number of instrument and electrical equipment preferred vendors and model numbers or to select a specific manufacturer and model number for each equipment type, in order 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 readily available spares.
- 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 Equipment Numbering

- 3.5.1 All electrical equipment and instruments shall be identified with a unique instrument / equipment tag number according to the Particular Specification and Process and Instrumentation Diagrams.

- 
- 3.5.2 These tag numbers shall be used to identify the instruments on the equipment itself and its mounting locations.
 - 3.5.3 Tag numbers shall carry through the entire design, appearing consistently on drawings, manuals, documents, labels, controller software, operator interfaces and data management systems.

3.6 Instrument Tags and Nameplates

- 3.6.1 All instruments, transmitters, control valves and actuator stations shall have a nameplate fitted to the instrument stand or adjacent structure.
- 3.6.2 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.
- 3.6.3 Name plate wording shall be in accordance with the project standards.

3.7 Instrument Power Supplies

- 3.7.1 Instrument power supply shall be 230VAC or 24VDC as stated in the particular specification, where the instrument is not loop powered, and 24 V DC for all loop powered instruments.
- 3.7.2 Loop powered instruments shall be powered from the control system that the instrument is connected too.
- 3.7.3 Separately powered instruments shall have individual miniature circuit breakers installed in the control panels feeding them, for protection of the supply cable, and in the field stations for protection and isolation of the instrument.
- 3.7.4 In hazardous locations, the power supply (and signal loop) to the instrument shall be intrinsically safe and wired to an appropriate intrinsic safety rated instrument. Where this is not practical in a single loop, intrinsic safety barriers shall be included in the loop design.

3.8 Process Isolation

- 3.8.1 Isolation valves shall be provided where practical so that process gauges and instruments can be removed for maintenance without draining tanks, pipes or reservoirs and without depressurising entire systems.
- 3.8.2 The first isolation valve for instrument connections shall be a full process rated piping valve (not an instrument valve).
- 3.8.3 Separate process connections are required for each instrument, including pressure gauges.
- 3.8.4 Process connections for instruments on vessels shall be dedicated to the instrument (Instrument bridles are not permitted) and not shared with process piping.

3.9 Transportation and Shipping

- 3.9.1 Removal of instrumentation fitted to package plant and equipment before shipment to site 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 connections and fittings.
- 3.9.2 Sensitive instrumentation may however require partial disassembly and special packaging for protection against vibration, environment, (sea) transport and potential handling damage.

- 
- 3.9.3 All equipment, sensors and transmitters shall be fully sealed for transport.
 - 3.9.4 A full set of reassembly, installation, commissioning and testing instructions shall accompany the equipment.
 - 3.9.5 The Instrument's installation shall be consistent with the project standard instrument installation details issued by the manufacturer.
 - 3.9.6 Loose instruments shall be separately packed in shipping crates that are dust-tight, moisture-resistant, and robust enough to withstand ocean shipment and warehouse handling, and to prevent damage to equipment.
 - 3.9.7 All electrical, electronic and electro-mechanical equipment shall be protected against ingress of moisture during shipping.

4. INSTRUMENT SENSORS

4.1 General requirements

- 4.1.1 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.
- 4.1.2 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.
- 4.1.3 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.
- 4.1.4 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.
- 4.1.5 Transmitted analogue outputs for recording, monitoring and control shall generally be 4-20 mA. When specified in the particular specification, instrument transmitters shall also provide a serial fieldbus type interface.
- 4.1.6 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).
- 4.1.7 The installation of 'wet' sensors and process pipe work into electrical control panels is strictly forbidden.

5. FLOW

5.1 General requirements

- 5.1.1 Any type of flow meter that is technically suited for the application may be considered for flow measurement.
- 5.1.2 All flow measurements expressed as ratios or that are cascaded with other process variable shall be linearized.
- 5.1.3 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.
- 5.1.4 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
 - c) The material flow velocity is at least 20% higher than the minimum flow velocity that can be accommodated with the specific instrument. Reducers and enlargers are permitted to ensure optimum flow velocity for the instruments.
- 5.1.5 The calculations for flow elements shall be done at the following standard reference conditions:
 - a) Flow liquids - 101,325 kPa abs @ 20 °C
 - b) For gas and vapours - 101,325 kPa abs @ 0 °C

5.2 Orifice plate flow installations

- 5.2.1 The upstream and downstream lengths of the orifice meter tubes for all applications shall be according to ISO 5167.
- 5.2.2 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.
- 5.2.3 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).
- 5.2.4 Orifice plates shall be installed between weld neck orifice flanges, of which the material shall be according to line class.

5.3 Electromagnetic Flow Meters

5.3.1 General

The instrument shall be of a type suitable for application in the media it is to operate in as stated in the particular specification. It shall have high stability properties and shall require minimal maintenance over extended periods.

The flow meters shall comprise of:

- a) Detector head

Locally mounted control unit, with either local or remote transmitter and display of current and accumulative flow (in litres per second and kilolitres respectively) as stated in the particular specifications. The control unit shall generate a 4 – 20 mA signal proportional to the flow reading (or fieldbus serial interface if selected in the particular specifications),



suitable for transmission to a remote PLC or DCS. If mounted outdoors, the control unit shall be mounted in a weatherproof box, with a shield protecting the glass display window from direct sunlight.

All power supply and signal cabling

All mountings, brackets, pedestals etc., required to install the equipment

5.3.2 Operating principle and construction requirements

- 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 transmitter.
- 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 (or other applications as stated in the particular specification) 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 self-cleaning. 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.

The transmitter shall be equipped with a digital current rate of flow indicator (in litres per second, but configurable for other units), preferably of the LCD type, a non-resettable flow totalizer (in kilolitres or cubic metres), shall also be provided as an isolated pulsed output for flow totalising.

- g) The instrument shall have a variable span facility with automatic zero control and a signal hold facility.
- h) The instrument shall preferably operate on a pulsed DC field or other means to reduce power consumed and prevent electrode polarisation and zero drift.
- i) The electromagnetic flow meter shall be capable of withstanding the test pressure experienced during mains testing without impairing operating performance.

5.3.3 Installation requirements

- a) The control unit shall be mounted on the flow meter tube, and the transmitter on either the tube or remotely in a weatherproof box as called for in the particular specification, with a shield protecting the glass display window from direct sunlight.
- 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 velocity in the pipe is too low for the flow meter to register, either a flow meter with smaller diameter or pipe reducers and enlargers shall be considered upon approval 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 8°) and stainless steel support brackets. All couplings and flanges shall be wrapped in Denso Tape.

- e) The lining of the flow meter tube 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) If the flow meter is to be installed in a nonconductive pipe that is not grounded, a suitable local earth connection 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 electromagnetic flow meters are installed, 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 meter head and shall provide earthing continuity.
- h) The instrument installation shall include all interconnections and sundry requirements between sensor and controller / transmitter unit.
- i) Electromagnetic flow meters shall be rated for continuous submergence to 5 m depth, and shall be suitable for installation in open air or enclosed flow meter chamber.
- j) Electromagnetic type flow meters installed in manholes/chambers shall be rated with Type IP68 Environmental Protection.
- k) When the electromagnetic flow meter is to be installed in a flow meter chamber, the Contractor shall provide details to the Civil Contractor on how the manholes and chambers should be constructed. All puddle flanges, pipe flanges and reducers / enlargers (if required) shall be supplied and installed by the Contractor.
- l) The Civil Contractor shall be responsible for proper drainage of any water in the flow meter chambers or 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.

5.3.4 Accuracy

The accuracy of the instrument shall be guaranteed to be equal or better than:

- a) $\pm 0,5$ % of measured flow in the flow range 50 – 100 %
- b) $\pm 0,1$ % 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.

5.3.5 Maintenance

The instrument shall be maintenance free.

5.4 Mass Flow Meters

5.4.1 General

- c) The instruments shall be of a type specially developed for application in water and waste water treatment, mining and processing plant as called for in the particular specification. It shall have high stability properties and shall require minimal maintenance over extended periods.
- d) The meters shall be Coriolis type units, suitable for measuring the mass flow of the



specified parameter in the chemical solution over the specified range and shall include for density calibration.

The mass flow meters shall comprise of:

- e) Measuring unit/detector tube (curved or straight tube as called for in the particular specification).
- f) Control unit / transmitter, with display of instantaneous and totalized flow (in milligrams per second and kilograms respectively, or any other units as stated in the particular specification). 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 , OR a fieldbus type serial interface as called for in the particular specification.
- g) A remote transmitter option with weatherproof enclosure if and when installed outdoors.

5.4.2 Operating Principle

The meters shall operate using the Coriolis mass flow principle.

5.4.3 Construction

The transmitter enclosure shall be rated at IP 65.

5.4.4 Installation requirements

- h) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.
- i) The sensor shall be factory calibrated before being installed and shall be supplied with valid up to date calibration Test Certificates.
- j) Sufficiently long sensor leads / wiring shall be supplied with the instrument to facilitate the remote transmitter installation when called for in the particular specification.
- k) 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.

5.4.5 Accuracy

The precision shall be ± 3 % of the measured mass.

5.4.6 Maintenance

Coriolis meters shall require minimal maintenance and calibration only every three years however the Contractor shall adhere to and include for any maintenance required by the specific instrument vendor during the contract period.

5.5 Ultrasonic Open Channel Flow Meters and Level Meters

5.5.1 General

- a) All ultrasonic open channel flow meters shall be microprocessor based, non-contact level meters and be able to be programmed to calculate flow accurately for material passing through any type of flume or over any type of weir.
- b) When measuring flow through a flume or weir, the measured flow shall be based on the change in level in the approach section to the flume or weir plate.
- 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.

5.5.2 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 off 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.

5.5.3 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 purpose designed obstruction with a known relationship between height of medium and flow rate. (For this purpose a ten point look-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 microprocessor based, 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 associated controller (PLC).
- g) A galvanically isolated 4-20 mA output, linear to flow or level shall be provided for remote indication and processing, as well as a serial fieldbus interface when called for in the particular specification.
- 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 if material turbulence results in unstable readings.
- 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.

5.5.4 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 by the specific instrument supplier's installation instructions, or called



for in the particular specification, a suitably dimensioned stilling well shall be supplied and installed with the transducer.

- c) The Contractor shall conform to the manufacturer's recommended instructions for the positioning and mounting requirements for the installation of the flow meter.
- d) The installation shall include for all required interconnections and sundries between the sensor and control unit.

5.5.5 Accuracy

The accuracy of the level measurement shall be better than 0,25 % of full scale.

5.5.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 3 months), no other maintenance should be necessary.

5.6 Ultrasonic Area Velocity Flow Meters

5.6.1 General

- e) All area velocity flow meters, whether installed in open channels or pipes shall be microprocessor based and be able to be programmed to read flow accurately for the material passing through any type of channel or inside any type of pipe, or to read level and area velocity accurately in an irregularly shaped container.
- f) Before calibrating the meters, the Contractor shall take accurate measurements with the help of a laser (accurate to 1 mm) of the relevant civil structure used for the meter installation. The exact structure size must be used for programming the controller, especially when new instruments are installed on existing channels / pipes.

5.6.2 Operating principle

- g) A burst of two separate ultrasonic pulses are transmitted from a transducer head, which is in contact with the medium, submerged and mounted at the bottom of the pipe/channel.
 - i) The first of these pulses are reflected off the top surface of the medium and received by the same transducer below. 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, allows the level to be calculated.
 - ii) The second of these pulses are transmitted as bursts at a 45 degree angle toward the flowing liquid. The time delay between the transmitted and received signal combined with the associated phase shift of the signal is proportional to the flow between the transmitter/receiver, which is fixed, and the medium, which is variable. The compensation of the phase combined with the time delay allows for accurate flow measurements.
- h) To compensate for the temperature dependence of the ultrasonic signal, the liquid temperature shall be measured at the transducer and shall be taken into consideration when the level difference is calculated between transmitter and medium.
- i) The minimum conductivity of the liquid, for correct use, shall be expected to be at least 100 $\mu\text{S/cm}$. These conditions are fulfilled by practically all conductive liquids, such as water/wastewater, acids etc, with the exception of pure solvents, where this instrument is not suitable.

5.6.3 Construction

- j) The ultrasonic transducer shall include a built-in temperature sensor and shall have a minimum enclosure rating of IP 68. The transducer shall be corrosion protected as well

as immune against UV radiation.

- k) The level calculation shall be temperature compensated.
- l) For flow application, the instrument shall provide for the following standard primary flow elements:
 - v) Pipes
 - vi) Open channels
- m) 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)
- n) 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.
- o) In addition to the above, for flow meter applications, a galvanically isolated pulsed output shall be provided to the remote controller.
- p) A galvanically isolated 4-20 mA output, linear to flow or level shall be provided for remote indication and processing, and a serial fieldbus type interface provided when called for in the Particular Specifications.

5.6.4 Installation requirements

- q) The ultrasonic transducer shall be supplied complete with mounting materials. The mounting method shall be rigid and ensure a tight bond between the sensor and the pipe or open channel.
- r) The Contractor shall conform to the manufacturer's recommended instructions for the positioning and mounting requirements for the installation of the flow meter and sensor.
- s) The installation shall include for all required interconnections and sundries between the sensor and control unit.

5.6.5 Accuracy

The accuracy of the level measurement shall be better than 0,25 % of full range. Velocity measurement shall be 2% of full range.

5.6.6 Maintenance

Maintenance free.

5.7 Averaging Pitot Tube Gas Flow Meters

5.7.1 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.

5.7.2 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 Bernoulli's theorem, the flow rate can be calculated.

5.7.3 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 its 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 totalizer.
- i) The instrument shall generate a galvanically isolated linear to flow 4-20 mA output for remote indication and calculation and a serial fieldbus interface when called for in the particular specification.
- 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 a dedicated instrument enclosure.

5.7.4 Installation

- l) 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.
- m) 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.
- n) 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.

5.7.5 Accuracy

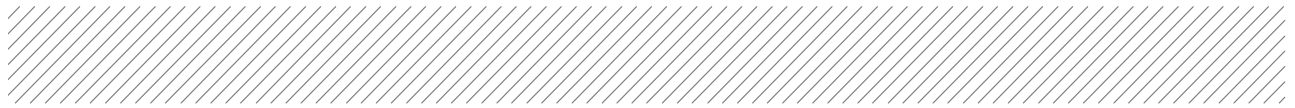
An accuracy of better or equal to $\pm 1\%$ shall be maintained over a flow turn down of greater than 10 to 1, independent of the Reynolds number. The repeatability of the instrument shall be equal or better than $\pm 0,1\%$.

5.7.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

5.8 Mechanical Flow Meters

- 5.8.1 Mechanical flow meters shall consist of the paddle or turbine type and shall only be used where a non-mechanical type flow meter cannot achieve the required flow metering function. For example when no interconnection to a programmable control system or SCADA is required.



5.9 Flow Switches

5.9.1 Flow switches shall be of the mechanical paddle type or electronic calorific (thermal) type.

6. LEVEL

6.1 General requirements

- 6.1.1 Level measurement shall be either by contact or non-contact means depending on the material being measured and the requirements in the Particular Specification.
- 6.1.2 The instrument offered shall be simple to install and maintain and shall be immune to interferences from disturbances in the medium being measured and / or any other process equipment that may be located in the level measurement zone.
- 6.1.3 The instrument shall generally comprise of a level measurement sensor connected to a level transmitter with local read-out and current loop process measurement signal connected to the associated programmable control, or serial fieldbus type interface (when called for in the particular specification.)
- 6.1.4 The instrument shall be robust and rated appropriately for the medium that it measures, whether corrosive or non-corrosive, accessible or inaccessible, pure or contaminated.
- 6.1.5 Level instrumentation shall provide 4..20mA current output signals as well as optional (configurable) potential free level switch options as called for in the particular specification and indicated on the technical data sheets.

6.2 Ultrasonic and Radar Level Meters

6.2.1 General

Non-contact level measurement shall be required for materials with high contaminant and corrosive properties such as sewage, sludge and aggressive chemicals.

6.2.2 Operating Principal

The level of the medium shall be measured by a sensor installed at a predetermined height above the highest point of the material being measured, and emitting either a high frequency sound wave (ultrasound) or high frequency electromagnetic wave (radar) onto the medium and then measuring the time of return flight and /or reflected wave properties in order to provide a level reading.

6.2.3 Construction

- a) The level transducer and transmitter shall form a single unit unless specified differently in the particular specification
- b) Coatings shall be applied to exposed surfaces that may be subject to damage from the process material being measured.
- c) Where necessary and practical to provide, the ultrasonic sensor shall include a stilling well in order to minimize surface disturbance that may affect the reading, and radar type sensor shall include a wave guide fixed from the sensor to the bottom of the vessel in order to improve accuracy and material properties of the medium being measured.
- d) The complete Enclosure shall provide a minimum IP55 rating, be provided with a robust steel or cast alloy corrosion free housing and shall be capable of an operating temperature range from 0 to 60 deg Celsius.

- e) The Transmitter shall comprise of a head mount electronics unit and provide the option of a remote transmitter. Where the instrument is inaccessible on top of structures or vessels it shall include a remote transmitter that shall be installed in a dedicated instrument enclosure at the bottom of the tank or vessel or other easily accessible location.
- f) Preference shall be given to a unit that is "smart" in that calibration and diagnostic checking shall be by hand-held calibrator.
- g) The transmitter shall have the ability to linearize the O/P depending on the geometry of the vessel, and thus relate O/P to either level or volume.
- h) The ability of the system to be configured to ignore unwanted signals from obstructions or agitators is essential.
- i) The instrument shall provide a 4-20 mA current loop signal into a 250 ohm load, or a serial fieldbus interface where called for in the particle specification.
- j) Power Supply shall be preferable 24V DC, loop powered, or otherwise separately powered via 230VAC single phase 50 Hz if called for in the particular specification.

6.2.4 Installation

- a) Suitable support brackets shall be supplied for all types of ultrasonic and radar transducers and these shall be installed well above their minimum measurement range (blocking distance)
- b) Alternative mounting methods (e.g.: suspension) may be required in some applications.

2.1.4 Accuracy

- a) Calibration Adjustments : Independent for Zero & span
- b) Accuracy : 1% of span or better
- c) Repeatability : 0.2% of span
- d) Dead Band : <0.2% of span
- e) Ambient Temperature Effect : <0.5% of maximum span per 10°C

6.2.5 Maintenance

- a) Ultrasonic and Radar level instruments shall be maintenance free.

6.3 Capacitance Level Transmitter

6.3.1 General

Liquid level measurement by direct contact means, where the material being measured is non corrosive, shall be by capacitive level probes immersed in the media. Where non-conductive vessels are used, a counter-electrode shall be supplied and installed into the vessel. Probes (rods) shall be of a material that is compatible with the process media. Coatings, such as Teflon, shall be used to protect the rods in most applications.

6.3.2 Operating principal



Capacitive level measurements shall comprise of single or multiple probes (dielectric sensors) in configuration such that the capacitance over the length of the probes changes with a change in level of the material they are immersed, in and such capacitance change shall be converted into a continuous level measurement. The material being measured shall provide a known dielectric property suitable for capacitive type measurements.

2.2.2 Construction

- a) Probe materials shall be Stainless steel with Insulation sheath of PTFE
- b) Insertion Lengths shall be provide to suit the application and as specified in the technical data sheets
- c) Level transmitters shall be of electronic type for rod or rope probe connection. Preference shall be given to a unit that is "smart" in that calibration and diagnostic checking shall be by hand-held calibration.
- d) A minimum ingress protection rating of IP55 shall be provided.
- e) The instrument shall provide a 4-20 mA current loop output into a 250 ohm load and a serial fieldbus type interface if called for in the particular specification.
- f) Power Supply shall be preferably loop powered at 24V DC
- g) Temperature range shall be 0 to 150°C
- h) The instrument shall be suitable for installation in a pressurized container up to a maximum process pressure of 1000 kPa

6.3.3 Installation

- a) The instrument shall include various mounting (process connections) to suit the application and requirements in the particular specification.

6.3.4 Accuracy

- a) The measurement shall provide an accuracy to 1% of span or better
- b) Measurement repeatability shall be at least 0.2% of span
- c) Dead Band shall be <0.2% of span
- d) Ambient temperature effect on the reading shall be <0.5% of maximum span per 10°C change

6.3.5 Maintenance

- a) Capacitive level probes shall require no maintenance other than regular cleaning of the probes.

6.4 Hydrostatic Liquid Level Meters

6.4.1 General

Hydrostatic level probes shall be of submersible type suitable for use in water and wastewater applications with concentrations of up to 4% solids. The level probes shall be provided with integrated electronic insert and shall be used for point level detection of and be suitable for



aggressive environment with high and increasing temperatures and pressures. These transmitters shall specifically be designed to operate while continuously submerged in liquids.

- b) The sensor's electrodes shall be constructed from titanium or 316 stainless steel and insulated with spacers, separators or holders of ceramic, polyethylene and Teflon-based materials as called for in the particular specification.
- c) The instrument sensor shall be fixed away from and immune to moving parts of the other equipment in the tank.

6.4.2 Operating principle

- a) The measurement of level operates on the hydrostatic pressure principle based on the hydrostatic effect from the weight force of a stationary non-flowing liquid that distributes proportionally through-out the vessel.
- b) The hydrostatic sensor shall be of type dry ceramic measuring cell whereby the pressure acts directly on the robust ceramic isolating diaphragm. The deflection of the ceramic diaphragm creates a proportional variation in capacitance of the sensor.
- c) For pressure sealed vessels where level measurements occur, any changes in the air pressure of the enclosed gas phase above the liquid shall be compensated for by means of an integrated differential pressure sensor.
- d) For pressure of an open, vented vessel where level measurements occur, the atmospheric pressure compensation shall be made via a compensation pressure tube that connects to the instrument transmitter junction box. This tube shall be kept clear of blockage or kinking and special consideration shall be made to protect against condensation by means of Teflon filters, similar or equivalent.

6.4.3 Construction

- a) The equipment shall be provided with a built-in temperature sensor (PT100 resistance temperature device) and shall have a minimum enclosure rating of IP 68. The transducer shall be corrosion protected as well as immune against UV radiation.
- b) The level calculation shall be temperature and pressure compensated.
- c) For level applications, the instrument shall be equipped with a local level indicator and an 8 digit controller. If the controller consists of a microprocessor, it shall be supplied with a minimum of 24 hour battery backup to prevent data loss in the event of power failure.
- d) A galvanically isolated 4-20 mA output, linear to level signal shall be provided for remote indication and processing, and a serial fieldbus interface provided if called for in the particular specification.
- e) 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.

6.4.4 Installation requirements

- a) The equipment probe installation shall be vertically from above.
- b) The equipment shall be supplied complete with mounting screw/bracket and cable clamp. The mounting frame shall be rigid and made from stainless steel. The equipment shall be mounted in such a way that it is free from all handrails, walkways, etc.
- c) The equipment shall be provided and installed with a DN200 uPVC (Class 12) pipe protection baffle.
- d) The Contractor shall conform to the manufacturer's recommended instructions for the positioning and mounting requirements for the installation of the equipment.
- e) 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 0,20 % of full scale.

6.4.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

6.5 Level Switches

6.5.1 Any type of level switch that is technically suited for the application shall be supplied for discrete level measurement.

6.5.2 Acceptable switching method shall be conductive, float based micro switch, vibrionic, and hydrostatic pressure.

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 stated otherwise in the particular specifications and instrument data sheets. 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) Instruments shall be indicating, electronic type based on capacitance or piezo electrical 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.

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 with mechanical switch for bulk materials, and charge or pressure mode switches using capacitive or piezoelectric principal for fluids and gasses.

8. TEMPERATURE

8.1 Temperature meters

8.1.1 General

The instruments shall be suitable for measuring temperature in containers and pipes and on machinery and bearings. The temperature probes shall be installed in temperature wells or otherwise embedded in the mechanical equipment (e.g. motor windings).

8.1.2 Operating principle

The temperature probes shall be of the RTD type complete with a suitable temperature transmitter.

8.1.3 Construction

- a) Temperature transmitters shall be either integral to the temperature instrument (e.g. head mount) or otherwise separately rail mountable in an associate instrumentation enclosure)
- b) 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.
- c) The temperature transmitter shall be equipped with a digital local temperature indicator if called for in the particular specification and shall be provided either integral with the instrument or otherwise in a seven segment signal loop connected display on the instrument enclosure.

8.1.4 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 sensor.

8.1.5 Accuracy

The accuracy of the temperature measurement shall be better than 1 % of full scale deflection.

8.2 Thermocouples

8.2.1 Thermocouples shall be:

- a) Chromel-alumel (ISA Type K) for temperatures between -70 °C and +900 °C.
- b) Platinum / 10 % rhodium platinum (ISA Type S) for temperatures in excess of 900 °C.

8.2.2 All thermocouples shall be made from premium grade thermocouple wire.

8.2.3 Only thermocouples which are not grounded to the sheath shall be used.

8.2.4 Only duplex or triplex type thermocouples shall be used.

8.2.5 Thermocouple terminal heads shall provide the degree of protection against dust and moisture of IP 65. The heads shall be made of aluminium alloy.



8.3 Resistance temperature detectors

- 8.3.1 Three wire resistance temperature detectors (RTD) shall be used in applications where thermocouple performance can be influenced by electrical fields.
- 8.3.2 The choice between the use of thermocouples or RTF shall be based on the suitability for the application.
- 8.3.3 The choice for using RTD elements (100 Ω @ 0 °C) shall be limited to temperatures of -175 °C to +475 °C. 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.

8.4 Temperature signal transmitters

- 8.4.1 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.

8.5 Local temperature indicators

- 8.5.1 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.

9. ANALYTICAL INSTRUMENTS

9.1 Dissolved Oxygen Meters

9.1.1 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 minimal maintenance over extended periods.

9.1.2 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, and requiring a mechanical cleaning mechanism will not be acceptable.

9.1.3 Construction

Sensor probes making use of opto luminescent sensing shall be used.

- a) A polyurethane coating on the sensor shall protect the sensor from sunlight.
- b) 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.
- c) The construction of the probe shall be such that there is a continuous circulation of the medium past the optical sensor. More than 98 % of the volume of medium surrounding the sensor shall be displaced in less than 2 minutes.
- d) The dissolved oxygen shall be suitable to measure the dissolved oxygen level up to 5 m below the surface of the medium.
- e) The probe shall include a temperature sensor for automatic measurement compensation.

9.1.4 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.

9.1.5 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.

9.1.6 Maintenance

Other than the cleaning of the sensor every 90 days and replacement every 2 years, no other maintenance should be required.

9.2 pH Meters

9.2.1 General

The instruments shall be of a type specially developed for application in water and waste water treatment plants. It shall be of the in-line type and require minimal maintenance over extended periods.

The meters shall comprise:

- a) Measuring unit/detector head/probe utilizing differential multiple electrode measurement technology.
- 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, or serial fieldbus data interface if called for in the particular specification.
- 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

9.2.2 Construction

- a) The transmitter enclosure shall be rated at IP 65.
- b) The probe shall include a temperature sensor for automatic measurement compensation.

9.2.3 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.

9.2.4 Maintenance

Other than the cleaning of the sensor at regular intervals (90 days) and replacement of the sensor reagent bridge (12 months), no other maintenance should be required.

9.3 Turbidity Meters

9.3.1 General

The instruments shall be of a type specially developed for application in water and wastewater treatment plants. It shall have high stability properties and shall require minimal maintenance over extended periods.

The meters shall comprise:

- a) Measuring unit/detector head/probe, either immersed or in a sampling system enclosure.
- 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, or serial fieldbus data interface when called for in the particular specification.
- c) Immersion probe type sensor or 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; as called for in the particular specification.
- d) A self-cleaning system.
- e) A weather proof instrument enclosure, in which the transmitter (and sampling / measuring and control units if called for in the particular specification) are to be installed.

9.3.2 Operating principle

- a) Water shall flow over the immersed sensor, or be taken from the main pipe line through a self-priming feed water supply pump drawing sample water from the sampling point to the sensor and transferring it to the measuring unit and back to the main flow system, preferably the plant 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.

9.3.3 Construction

- a) The sensor shall be constructed of a PVC housing with glass sensor window and include a stainless steel wiper with silicon rubber blade.
- b) The transmitter enclosure shall be rated at IP 65.

9.3.4 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.

9.3.5 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 $\pm 0.5\%$ or ± 0.008 NTU of the measured value.
- c) The response time shall be approximately 1 to 60 seconds.



The flow rate of sample shall be 0.2 to 1 L/minute.

9.3.6 Maintenance

- a) Other than the cleaning of the sensor monthly, and the replacement of the wiper blade and seal every 2 years, no other maintenance should be required.

9.4 Residual Chlorine Meters

9.4.1 General

The instruments shall be of a type specially developed for application in water and waste 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 or serial fieldbus data interface when called for in the particular specification..
- 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 instrument enclosure, in which the measuring and control units shall be installed.

9.4.2 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.
- b) An amperometric measurement principal shall be used with a probe consisting of electrodes separated by a membrane. A sample shall pass across the membrane to react with an electrolyte and cause a measurable current flow in the associated sensor electrodes.
- c) The measurement principal shall preferably be pH neutral thereby eliminating the need for buffer solutions and reagents.

9.4.3 Construction

- a) The transmitter enclosure shall be rated at IP 65.

9.4.4 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.

9.4.5 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.

9.4.6 Maintenance

Other than the cleaning of the sensor every 90 days, the replacement of the electrolyte every 3 to 6 months and the replacement of the membrane every 12 to 18 months, no other maintenance should be required.

9.5 Chlorine Leak Detector

9.5.1 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:

- 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) A weather proof box, in which the measuring and control units are to be installed.
- d) 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.
- e) 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.
- f) The design shall be modular to allow single and multi-point detection.
- g) The detector shall be supplied with battery back-up for at least 4 hours.
- h) A local display shall indicate the level of chlorine concentration in the area.

9.5.2 Operating principle

The sensor shall utilize an electro-chemical detection principal and 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.

9.5.3 Construction

The transmitter enclosure shall be rated at IP 65.

9.5.4 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 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.

9.5.5 Accuracy

The chlorine leak detector shall be suitable for measuring the chlorine in the atmosphere to within 3 % of the actual value.

9.5.6 Maintenance

Other than the cleaning of the sensor every 90 days, no other maintenance should be required.

9.6 Streaming Current Detector

9.6.1 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.

9.6.2 Operating principle

The SCD analyser detects the electro kinetic charge of a solution to monitor suspended solids and control the addition of flocculants.

9.6.3 Construction

The transmitter enclosure shall be rated at IP 65.

9.6.4 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.



9.6.5 Accuracy

The chlorine leak detector shall be suitable for measuring ion charge within 3 % of the actual value.

9.6.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

9.7 General

- 9.7.1 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.

10. ANALYSER STATIONS

10.1 General

10.1.1 Where specified, analyser instrumentation shall be grouped together into an analyser station. An analyser station shall consist of the following:

10.1.2 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

10.1.3 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.

10.1.4 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.

10.1.5 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.

10.1.6 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.

10.1.7 Analyser Enclosure

- a) The analyser enclosure shall be rated IP55.

- 
- 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.

10.1.8 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.



11. WEIGHING INSTRUMENTS

11.1 Load Cells

11.1.1 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.



12. PROCESS CONNECTION LOCATIONS

12.1 General

- 12.1.1 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.
- 12.1.2 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.

12.2 Orientation of connections

- 12.2.1 Connections shall be oriented so that instruments or piping shall not obstruct aisles, platforms or ladders.

12.3 Field mounted transmitters

- 12.3.1 All field mounted transmitters shall be installed so that they are accessible from grade, platform or permanent ladders.

12.4 Control valves

- 12.4.1 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.

12.5 Clearance for adjacent equipment

- 12.5.1 Clearance shall be provided at flow meter offices for valves or other components that may be located adjacent to the line.

12.6 Vessel connections

- 12.6.1 Connections on vessels for gauge glasses and level instruments shall be oriented to minimise the effect of inlet and outlet streams of the instruments.

12.7 Instrument accessibility

- 12.7.1 All instruments requiring adjustment shall be accessible for servicing from grade, walkways, permanent ladders, or platforms.
- 12.7.2 Flow meter primary devices, thermal system bulbs and thermocouples shall be accessible from walkways, permanent ladders, platforms or grade.

12.8 Instrument orientation

- 12.8.1 Instruments shall face the operating area so that the response to process adjustments can be observed from the operating area.
- 12.8.2 All instruments installed outdoors shall be installed so that the display faces south if practical.

13. DRAWINGS AND DOCUMENTATION

13.1 Drawings and design documentation

- 13.1.1 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.
- 13.1.2 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied.
- 13.1.3 Manual formats shall be A4 size on the filing side which shall be vertical with 20 mm margin for filing.

13.2 Drawings and Documentation for Approval by the Engineer

- 13.2.1 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

13.3 Operating & Maintenance Manual

- 13.3.1 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.



13.4 Certification

- 13.4.1 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
- 13.4.2 The Contractor shall guarantee that all products shall be suitable for the intended application and shall be capable of the duties specified.
- 13.4.3 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.

14. INSPECTION, TESTING AND CALIBRATION

14.1 General requirements for testing

- 14.1.1 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.
- 14.1.2 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.
- 14.1.3 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.
- 14.1.4 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.
- 14.1.5 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.
- 14.1.6 Any damage to plant or equipment during commissioning by the tests shall be rectified by the Contractor.
- 14.1.7 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.
- 14.1.8 The Contractor shall ensure that all necessary spares are available on site during commissioning.
- 14.1.9 Four copies of final test results shall be issued to the Engineer in an appropriate and approved format
- 14.1.10 Instrument data sheets are to be 'as built' and material plus test (pressure, leak, and hazardous area) certificates and calibration sheets are to be provided for each instrument in accordance with the data sheets.
- 14.1.11 The equipment shall be tested and commissioned together with the relevant pipework and other equipment such as pumps or compressors.
- 14.1.12 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.
- 14.1.13 Key non-standard set-up parameters shall be noted on the instrument data sheet.
- 14.1.14 A calibration sticker shall be placed on all shop tested and calibrated instruments.

- 
- 14.1.15 The Contractor shall be responsible for all instrument calibration on site if the instrument requires adjustment or further calibration.
 - 14.1.16 All cables shall be insulation and continuity tested before being connected at either end.
 - 14.1.17 Wherever possible instrumentation once installed shall be fully checked and tested in service and test sheets completed.
 - 14.1.18 After completion of installation, the Contractor shall provide evidence of the satisfactory operation of all equipment before the site acceptance certification be validated.

14.2 Visual checks

- 14.2.1 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.

14.3 Static tests - Instrument air supply lines

- 14.3.1 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.

14.4 Functional tests

- 14.4.1 Functional testing shall be conducted to confirm all equipment operates as per the Control Philosophy and the Test Sheets.
- 14.4.2 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.
- 14.4.3 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.

- 14.4.4 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.

14.5 Field Instruments

- 14.5.1 For transmitting instruments, a simulated process input of 0, 25, 50, 75 and 100 % both rising and falling shall be injected into the transmitter.
- 14.5.2 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.
- 14.5.3 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.
- 14.5.4 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.
- 14.5.5 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.
- 14.5.6 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
- 14.5.7 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.
- 14.5.8 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.
- 14.5.9 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.
- 14.5.10 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).
- 14.5.11 In line instruments and control valves must be replaced by spools while process lines are cleaned and tested.
- 14.5.12 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.



14.6 Control Components

- 14.6.1 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).
- 14.6.2 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.
- 14.6.3 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.
- 14.6.4 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.
- 14.6.5 Control loops shall be tested to confirm control action and to ensure that the dynamic response is suitable for the process being controlled.
- 14.6.6 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.
- 14.6.7 All devices shall be tested to ensure that indications and alarms function correctly.



Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre

1 Century City Drive

Waterford Precinct

Century City

Cape Town

7441

PO Box 494

Cape Town

8000

South Africa

T +27 21 526 9400

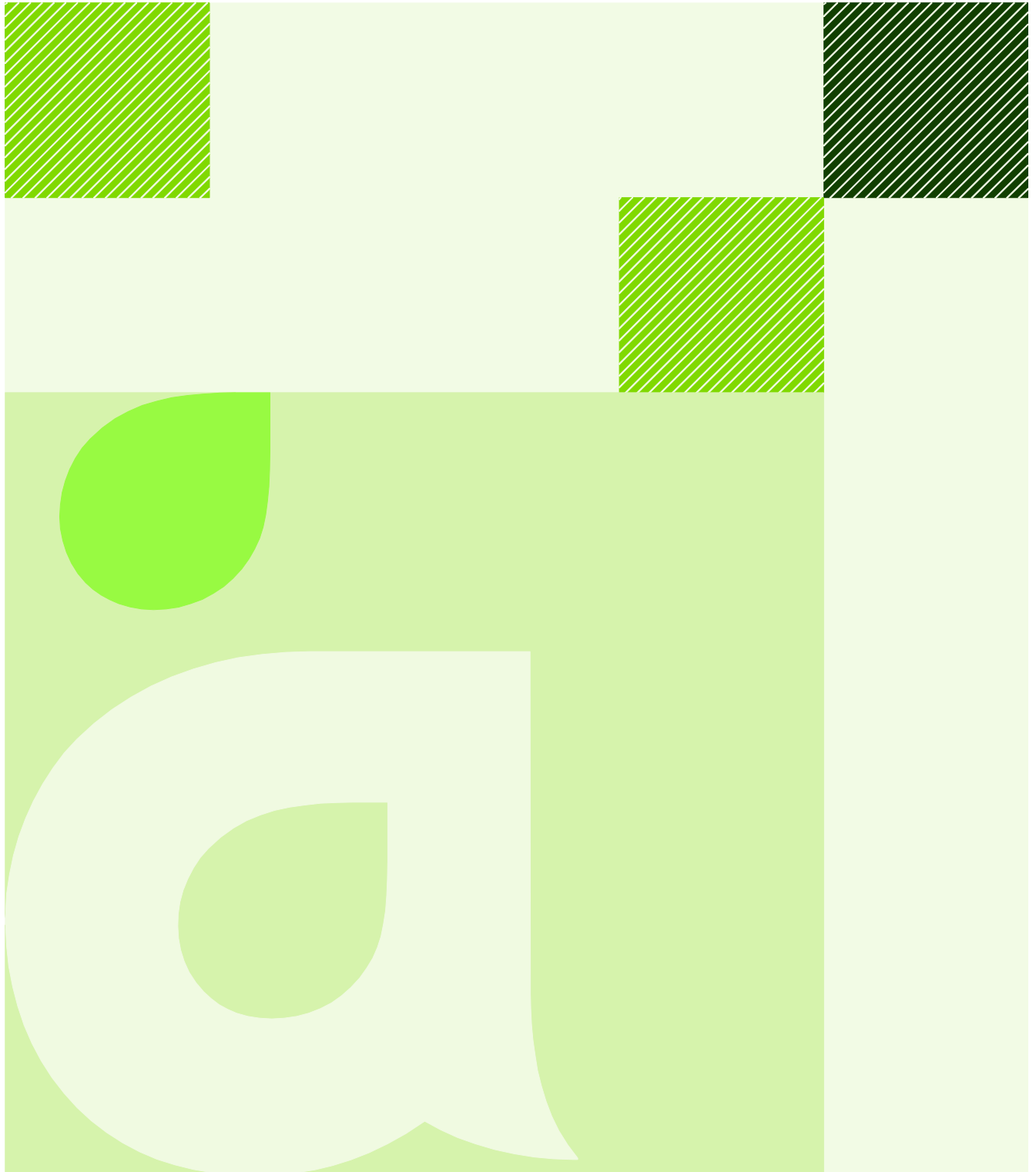
F +27 21 526 9500

E capetown@aurecongroup.com

W aurecongroup.com

Aurecon offices are located in:

Angola, Australia, Botswana, Chile, China,
Ethiopia, Ghana, Hong Kong, Indonesia,
Lesotho, Libya, Malawi, Mozambique,
Namibia, New Zealand, Nigeria,
Philippines, Qatar, Singapore, South Africa,
Swaziland, Tanzania, Thailand, Uganda,
United Arab Emirates, Vietnam.



Engineering Standard

Programmable Logic Controllers (PLC)

25 June 2015

Revision: 0

Reference: II-0002

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

- a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
- b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control						aurecon
Specification title		Programmable Logic Controllers (PLC)				
Document ID		II-0002	Reference number		II-0002	
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD				
Rev	Date	Revision details/status	Prepared by	Author	Verifier	Approver
0	25 June 2015	First issue	M Kriel	K O'Kennedy	A Schröder	O Fair
Current revision		0				

Approval			
Author signature		Approver signature	
Name	Kenney O'Kennedy	Name	Owen Fair
Title	Electrical Engineer	Title	Technical Director

Contents

1. SCOPE	1
1.1 Application	1
1.2 General Requirements	1
2. STANDARDS	2
2.1 Associated Documentation	2
2.2 Statutory Requirements	2
2.3 Reference Standards	2
3. PLC HARDWARE	3
3.1 General	3
3.2 PLC I/O	4
3.3 PLC Remote I/O	4
3.4 PLC I/O circuits	4
4. PLC SOFTWARE	6
4.1 General	6
4.2 PLC software structure	6
4.3 PLC software control routines	7
4.4 PLC monitoring software	8
4.5 Functional Specification	9
5. INSTALLATION REQUIREMENTS	10
6. TESTING AND COMMISSIONING	11
7. DOCUMENTATION AND TRAINING	12

Tables

Table 1: Reference Standards	2
------------------------------	---

[Copyright 2015 Aurecon South Africa (Pty) Ltd. All rights reserved.]

The contents of this Document are both privileged and confidential and may not be disclosed or reproduced, except as expressly permitted in writing by Aurecon South Africa (Pty) Ltd. All requests should be sent to the attention of the Legal Department, Aurecon South Africa (Pty) Ltd, PO Box 74381, Lynnwood Ridge, 0040. In this regard the attention of every reader or recipient of this document is drawn to the provisions of the paragraph, which follows, the contents of which shall be binding on such reader and/or recipient.

Copyright subsists in this Document and all attachments hereto, which shall include all and/or any ideas, plans, models and/or intellectual property contained in this Document. Any unauthorised reproduction, adaptation, alteration, translation, publication, distribution or dissemination of the whole or any part of this Document in any manner, form or medium (including, but not limited to, electronic, oral, aural, visual and tactile media) whatsoever will constitute an infringement of Aurecon's copyright and other intellectual property rights. Aurecon reserves the right to take appropriate legal action in the event of any such unauthorised use.]



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 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 preferably 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

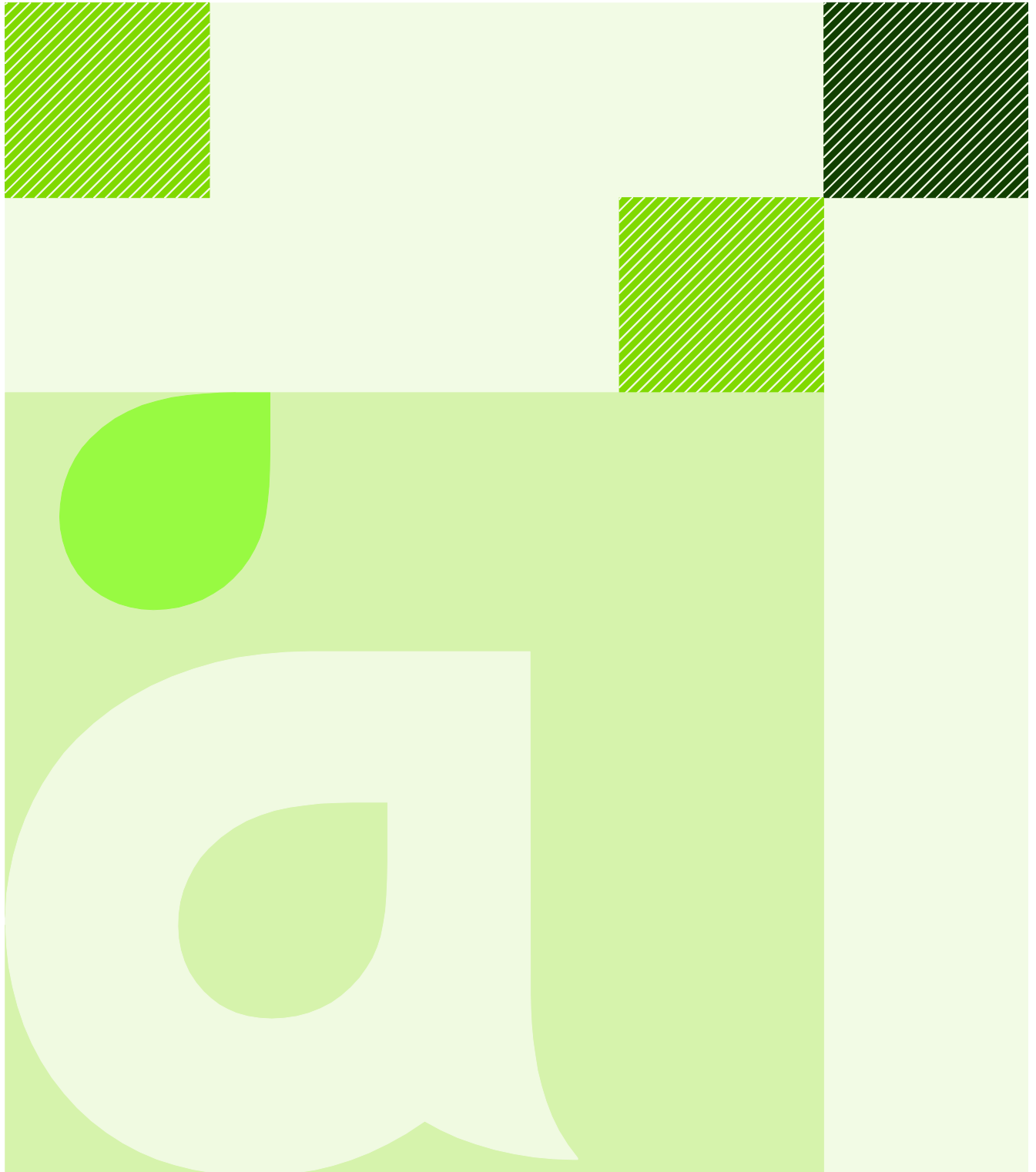
Comprehensive documentation, training and operations & maintenance manuals shall be provided for each PLC / PCS Assembly provided for the plant or works under this contract, all as described in the Engineering Specification SPE-II-0001 "General Electronic Installations".



Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:

Angola, Australia, Botswana, Chile, China,
Ethiopia, Ghana, Hong Kong, Indonesia,
Lesotho, Libya, Malawi, Mozambique,
Namibia, New Zealand, Nigeria,
Philippines, Qatar, Singapore, South Africa,
Swaziland, Tanzania, Thailand, Uganda,
United Arab Emirates, Vietnam.



Engineering Standard

Supervisory Control and Data Acquisition

25 June 2015

Revision: 0

Reference: II-0005

Document control record

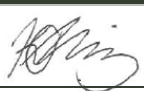
Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

- Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
- Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control							aurecon
Specification title		Supervisory Control and Data Acquisition					
Document ID		II-0005	Reference number		II-0005		
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	Date	Revision details/status	Prepared by	Author	Verifier	Approver	
0	25 June 2015	First issue	M Kriel	K O'Kennedy	A Schröder	O Fair	
Current revision		0					

Approval			
Author signature		Approver signature	
Name	Kenney O'Kennedy	Name	Owen Fair
Title	Electrical Engineer	Title	Technical Director

Contents

1. SCOPE	1
1.1 Application	1
1.2 General	1
2. STANDARDS	2
2.1 Associated Documentation	2
2.2 Regulations, Specifications and Standards	2
3. SCADA	3
3.1 General	3
3.2 SCADA System Hardware	5
3.3 System Software	7
3.4 SCADA Application Software	9
3.5 SCADA configuration for Process Visualisation and Operation	12
3.6 SCADA security	16
4. INSTALLATION REQUIREMENTS	18
4.1 General	18
5. TESTING AND COMMISSIONING	19
6. DOCUMENTATION AND TRAINING	20

Figures

Figure 1: Typical layout of a large system Control Desks and Computer Cabinets	7
--	---

Tables

Table 1: Reference Standards	2
------------------------------	---

[Copyright 2015 Aurecon South Africa (Pty) Ltd. All rights reserved.]

The contents of this Document are both privileged and confidential and may not be disclosed or reproduced, except as expressly permitted in writing by Aurecon South Africa (Pty) Ltd. All requests should be sent to the attention of the Legal Department, Aurecon South Africa (Pty) Ltd, PO Box 74381, Lynnwood Ridge, 0040. In this regard the attention of every reader or recipient of this document is drawn to the provisions of the paragraph, which follows, the contents of which shall be binding on such reader and/or recipient.

Copyright subsists in this Document and all attachments hereto, which shall include all and/or any ideas, plans, models and/or intellectual property contained in this Document. Any unauthorised reproduction, adaptation, alteration, translation, publication, distribution or dissemination of the whole or any part of this Document in any manner, form or medium (including, but not limited to, electronic, oral, aural, visual and tactile media) whatsoever will constitute an infringement of Aurecon's copyright and other intellectual property rights. Aurecon reserves the right to take appropriate legal action in the event of any such unauthorised use.]



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 arrester 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.

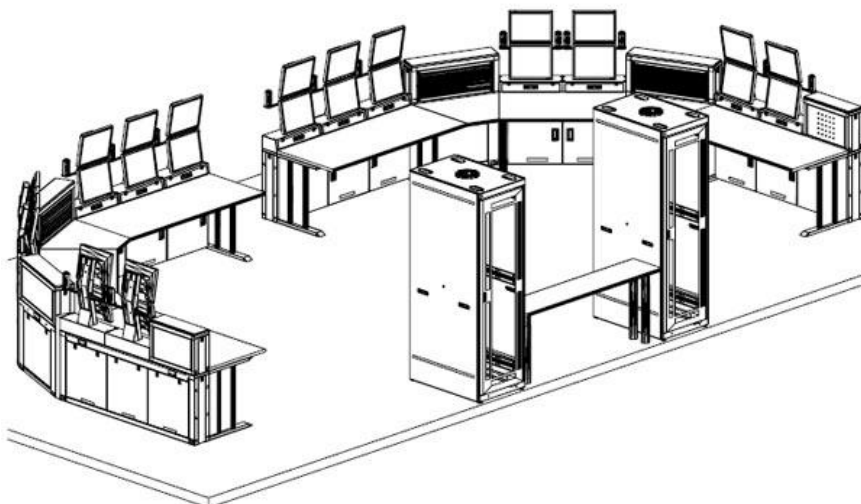


Figure 1: Typical layout of a large system Control Desks and Computer Cabinets

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 adds 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 COMMISSIONING

- 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”.



Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre

1 Century City Drive

Waterford Precinct

Century City

Cape Town

7441

PO Box 494

Cape Town

8000

South Africa

T +27 21 526 9400

F +27 21 526 9500

E capetown@aurecongroup.com

W aurecongroup.com

Aurecon offices are located in:

Angola, Australia, Botswana, Chile, China,
Ethiopia, Ghana, Hong Kong, Indonesia,
Lesotho, Libya, Malawi, Mozambique,
Namibia, New Zealand, Nigeria,
Philippines, Qatar, Singapore, South Africa,
Swaziland, Tanzania, Thailand, Uganda,
United Arab Emirates, Vietnam.