

C3.4.5

STANDARD SPECIFICATIONS FOR CONTROL AND INSTRUMENTATION WORKS

PARTICULAR SPECIFICATION FOR CONTROL AND INSTRUMENTATION**TABLE OF CONTENTS**

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PART IA GENERAL SPECIFICATIONS

IA1 DESCRIPTION OF WORK

IA1.1 Related Documents

The requirements of the General Conditions, Supplementary Conditions, Technical Specifications, and Drawings apply to all Work herein and forms part of the scope of work.

IA1.2 Scope

IA1.2.1 General Scope

A. Overview

Provide all labour, materials, tools, machinery, equipment, supplies, transportation, storage, utilities, appliances, hauling, hoisting, excavation, backfill, supervision, and services necessary to complete the Control and Instrumentation (C&I) Work under this Contract. Coordinate Work with the Work of the other trades so as to resolve conflicts without impeding job progress.

B. Drawings and Documentation

Examine the Architectural, Structural, Mechanical, Plumbing, Electrical and C&I Drawings and other Sections of the Specifications in order to determine the extent of Work required to be completed. Failure to examine all the Contract Documents for this Project will not relieve the Contractors of the responsibility to perform all the Work required for a complete, fully operational, and satisfactory installation.

C. Project Location

The Work to be performed under this Contract is in connection with the construction and erection of the C&I installation at [HammarSDale WWTW](#), on behalf of [eThekweni Municipality](#).

D. Work Included

The Work includes, but is not limited to, the supply installation and commissioning of material and equipment associated with the following systems, equipment, and services:

IA1.2.2 Automation Systems

- a. PLC Hardware, installed in the PLC panels integral to the motor control centres. Fully equipped including all wiring, power supplies network switches, uninterruptible power supplies (UPS), trunking, din-rail, terminals, miniature circuit breakers (MCB's), surge protection devices (SPD) and all other requirements to provide a complete installation.
- b. Communication Backbone: fibre optic Ethernet based system installed on site interfacing the control equipment:
The scope includes the necessary cable, panels, network switches and all other equipment required to provide a complete installation. Fibre optic cabling will be installed in an underground sleeve system complete with manholes as required for access.
- c. Field Instrumentation: Supply, installation and commissioning of the required field instrumentation to support the plant automation requirements.
- d. Instrumentation reticulation including, cabling, racking, racking support, junction boxes, and instrument junction boxes.

IA1.2.3 System Intergration, Scada and Software Requirements

The following items and services are to be provided by a specialist system integration company, with a provisional sum included in the in the bill of quantities to cover the work.

- a. PLC, HMI and SCADA software development, factory acceptance testing (FAT), site acceptance testing (SAT) and commissioning.
- b. SCADA and database hardware, including server PC's, monitors and standard PC requirements.

- c. PLC and SCADA software licensing.
- d. Process commissioning

IA2 DESIGN CRITERIA

IA2.1 Quality Assurance

IA2.1.1 Codes and Standards

The following codes and ordinances were used in the design of the project and shall be complied with during construction of the project.

- a. The Occupational Health and Safety Act no. 85 of 1993, as revised, whereby SANS 10142 is enclosed.
- b. Government notices.
- c. The Local Government Ordinance 1939 (Ordinance 17 of 1939) as amended and the municipal by-laws and any special requirements of the local supply authority,
- d. The Fire Brigade Services Act 1993, Act 99 of 1987 as amend,
- e. The National Building Regulations and Building Standards Act 1977 (Act 103 of 1977) as emended,
- f. The Post Office Act 1958 (Act 44 of 1958) as amended,
- g. The Electricity Act 1984 (Act 41 of 1984) as amended,
- h. The Regulations of the local Gas Board where applicable.

IA2.1.2 Standards

Refer to standard specifications for general administrative/procedural requirements related to compliance with applicable standards. This Work and all materials shall meet the standards set forth in the applicable portions of the following recognized standards:

- a. Building Code – SANS 10400
- b. Electrical Wiring Code – SANS 10142
- c. All other relevant SANS Codes

IA2.2 Compliance with Standard Specifications

Except where otherwise specified, the equipment shall comply with the current editions of the relevant specifications of the South African Bureau of Standards and the British Standards Institution or the International Electro Technical Commission recommendations.

IA2.3 General Requirements

IA2.3.1 Safe Design and Standardization

All equipment supplied and installed under this contract shall be designed:

- a. To prevent any injury to personnel employed on the construction, operation, and maintenance of the plant.
- b. To facilitate inspection, cleaning, and repair of the equipment.
- c. To operate continuously and satisfactorily in the prevailing site conditions.
- d. To be able to withstand without damage such sudden variations of electrical load as may be met under normal working conditions, including short circuits and lightning strikes.
- e. To obviate risks of accidental short-circuits due to animals, birds, and insects.
- f. To avoid pockets in which water can collect in outdoor equipment.
- g. To avoid condensation in closed compartments by the provision of adequate ventilation or where necessary, heaters.
- h. Such that conductors can carry normal load and fault currents without overheating or other damage.
- i. Such that moving parts can be readily lubricated. Grease nipples shall be provided in accessible positions for this purpose.
- j. To be vermin proof.
- k. To be corrosion resistant.

IA2.4 Quality Of Materials and Workmanship

- a. All materials and equipment for this Contract shall be new and undamaged. Corresponding parts shall be interchangeable.
- b. Where so directed by the specification or by the Engineer, the Contractor shall provide samples and test certificates of materials for approval.
- c. The labour used by the Contractor shall at all times be adequately qualified and experienced for the particular task.

IA2.5 Fixings and Connections**A. Nuts and Bolts**

Metric size nuts and bolts shall be used unless otherwise specified. Each bolt or stud shall project at least one thread but not more than 6 mm from the nut. Special spanners shall be provided where nuts and bolts are not easily accessible. The nuts on the moving plant or plant subject to vibration shall be fixed by means of locknuts, "Loctite" or other approved locking method. Bolts and studs shall be adequately sized to carry the loads, which may be imposed on them.

B. Materials of Nuts and Bolts

Only stainless-steel nuts, bolts and washers shall be used for all electrical connections.

IA2.6 Non-Corroding Materials

- A. Non-corroding materials shall be used in the construction of outdoor equipment and plant. This includes all cable racks, trays, and clips,
- B. The permissible grades and alloys are as follows:
 - a. Stainless Steel: Grade 3CR12 or better
 - b. Extruded Aluminium: 6082-T6
 - c. Cast Aluminium: L-2520
 - d. Glass fibre: To the relevant SANS specification

IA2.7 Galvanising and Painting

- A. NO drilling, cutting, bending, punching, welding, and forming of the steel or any surface damage shall be allowed after galvanising or painting.
- B. All the steel work shall be prepared, hot dipped galvanised and painted using the processes as per manufacturers recommendations.

IA3 GENERAL PROCESS INSTRUMENTATION SPECIFICATION**IA3.1 Quality Assurance****IA3.1.1 Codes and Standards**

The process instrumentation supplied shall comply fully with the applicable SANS/IEC/IEEE specifications as set out in the table below and all equipment shall bear the mark of approval of the South African Bureau of Standards. The latest issue of the SANS/IEC/IEEE/ NRS codes will be applicable.

SANS 10142-1 : National Standards for the wiring of premises
SANS 1507 : Electric Cables (300/500V to 900/3300V)
SANS 1574 : Electric Cables Flexible cords and flexible cables
SANS 1411 : Material of insulated electric cables and flexible cords
SANS 1803-1 : Lugs and ferrules for insulated cables
SANS 60793 : Optical fibres
SANS 60794 : Optical fibre cables

ISO/IEC 14763-3 : Fibre optic testing
EN 50288 : Multi-element metallic cables used in analogue and digital communications and control
ISO/IEC SANS 11801:2002 : Information Technology – Generic cabling for customer premises
SANS 1091:2004 : National Colour Standard.
SANS 1274-2005 : Coatings applied by the powder-coating process.
SANS 1186 : Information and Safety Signs.
IEEE 802.3-2005 : Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications
IEEE 802.1AX : Link Aggregation
IEEE 802.1d : MAC Bridges
IEEE 802.1Q : VLAN Tagging
IEEE 802.1w : Rapid Spanning Tree Protocol
IEEE 802.1X : Port Based Network Access Control

IA3.2 Design Basis

IA3.2.1 General

- All panel mounted instrumentation and control equipment shall be capable of operating at the required capacity in ambient temperatures not exceeding 50°C and an average, over a period of 24 hours, not exceeding 40°C. The field mounted instruments and control equipment shall however, be suitable for operation under ambient temperatures not more than 55°C unless higher ambient temperatures are specifically stated in the Technical Specification.
- All equipment and accessories shall be designed to withstand the environment and operational conditions within the plant.
- Instrumentation sensing system shall be pneumatic or electronic. Electric signal transmission shall be of common standard and level or converted, where required to the common standard.
- Special care shall be taken to make the equipment enclosures proof against entry of vermin and insects (IP rating).
- The design shall include all reasonable precautions and provisions for the safety of operating and maintenance personnel as well as for their accessibility.

IA3.2.2 Panel Instruments

- It should be endeavoured not to have any panel instruments, but rather to make use of the PLC / SCADA. Where panel instruments are required for instance at a T/A set the following shall apply.
- Standard size instruments shall be used on the control panels to indicate, record and control the major portion of the process variables.
- Factory assembled panels or field assembled panels shall be furnished in accordance with Item XX of this specification.
- Process fluids shall not be piped directly to instruments in the control room.
- Where separate electric power supplies are required for critical electronic instrumentation systems, it shall be taken off the UPS supplying that area Instrumentation.

IA3.2.3 Field Instruments

- All field mounted instruments shall be weather-proof and dust-tight, suitable for use under ambient conditions prevalent in a specific plant area with a minimum of IP rating of 65.
- In plant areas giving rise to corrosive atmospheres, field mounted instruments such as transmitters, I/P converters, solenoid valves, pressure switches etc. shall be housed in steel boxes with IP65 rating. Piping and cable entries shall be made at the bottom of the box.
- All field boxes will be fitted with canopies.
- All valves and drives shall be correctly sized with a 50% turn down ratio.

IA3.2.4 Control Performance

- Automated production is performed by a distributed process control and information management system comprising supervisory computers and controllers linked to a distributed real-time network.

- b. Automatic control systems shall, in general, be of feedback type, however, feed-forward control shall be used when process time-lag conditions that exist in a feed-back system are not tolerable. Modes of control shall, in general, be proportional (P), proportional plus automatic reset (I), or proportional plus reset plus rate (D).
- c. All control loops shall be stable for all process conditions. Cyclic stability will not be accepted. Final value error shall be minimised whenever practical.

IA3.2.5 Metering Base and PCS Units

Pressure above 1 bar	-	kPa
Pressure below 1 bar	-	Pa
Draft	-	mm H ₂ O
Vacuum	-	kPa (abs)
Temperatures	-	°C
Flow (all gases)	-	m ³ /hr
Flow (steam and condensate)	-	kg/hr tonne/hr
Flow (liquids)	-	m ³ /h lt/sec
Flow base	-	based at 760mm Hg and 0°C
Level	-	% or m
Density	-	kg/m ³

IA3.2.6 Utilities

- a. Electrical power, available from the plant system is 3 phase 400 V and 1 phase 240 V, 50Hz. If the equipment is required to operate at any other voltage level, the necessary transformer and/or conversion units shall be included in the scope of supply by the Contractor.
- b. A power supply calculation shall be performed to determine the capacity of:
 - UPS capacity including battery.
- c. Standard voltage:

Main power supply	-	3 x 400/220 V 50 Hz
UPS Supply	-	1 x 220 V ± 5%, 50 Hz
Instrument Control Voltage	-	1 x 220 V ± 5%, 50 Hz
	-	24 V ±5%, DC
Digital Signals	-	24 V ±5%, DC
Analogue Signals	-	4 to 20 mA DC
- d. Clean instrument compressed air will generally be available, however where specific instruments may require air quality above the normal quality of plant instrument air or at a lower pressure than the plant instrument air the contractor is to ensure that all necessary regulators, dryers, separators and lubricators are allowed for.

IA3.3 **Panel Instrument Design**

IA3.3.1 Recorders

Recorders are not preferred, SCADA trends, i.e. Real Time and History trends should be available for all measured variables.

IA3.3.2 Controllers

Stand-Alone controllers, (panel mount controllers), are not preferred.

IA3.3.3 Indicators

Stand-Alone indicators, (panel mount electronic indicators), are not preferred.

IA3.3.4 Alarm Annunciator

Alarm display window shall be LED side lighted name plate type.

Each alarm system shall be equipped with flasher and horn and shall have provision for push-buttons to acknowledge, reset and test the system.

Visual alarms shall be located in the vicinity of monitored process conditions on graphics panels. Miscellaneous alarms shall be grouped into a common bank whenever practical.

Alarm initiating contacts shall be normally open, either fleeting or permanent type. For the case of power failure or wire break, closed safety circuit operation shall be applied wherever practical.

The response for alarm systems shall be less than 20 milliseconds.

Alarm annunciation systems shall be energised from a secure 24V DC or 220 V AC power supply source or UPS.

Client Preferences:

All alarm annunciation will take place on the PLC/SCADA, or HIM.

IA3.4 **Field Instrument Design – Transmitter Design**

IA3.4.1 Magnetic Flow Meter

Transmitter shall be indicating, electronic type based on law of induction.

Transmitter shall meet the following minimum requirements:

Accuracy:	0,5% of span or better
Repeatability:	0,2% of span
Output:	Linear
Ambient temperature effect:	Not to exceed 0,5% of maximum span per 10°C change.
Material:	
- Tube:	Stainless Steel
- Liner:	Teflon (depending on application)
- Electrode:	Hastalloy Tantalum

IA3.4.2 Vortex Shedding Meter

Transmitter shall be indicating, electronic type based on the Vortex shedding measuring principle.

Transmitter shall meet the following minimum requirements:

Accuracy:	0,2% of span or better
Repeatability:	0,2% of span
Output:	Linear
Ambient temperature effect:	Not to exceed 0,5% of maximum span per 10°C change.
Material:	
- Tube:	Stainless Steel
Vortex shedder:	Stainless Steel

IA3.4.3 Pressure Transmitter

Transmitter shall be indicating, electronic type based on force balance principle.

Transmitter shall meet the following minimum requirements:

Accuracy:	0,2% of span or better
Repeatability:	0,1% of span
Dead band:	Not to exceed 0,1% of span
Ambient temperature effect:	Not to exceed 0,5% of maximum span per 10°C change.
Proof Pressure:	200% of max. process static pressure.
Mounting:	Universal bracket type
Material:	Case, primary element and wetted parts shall be made of material that is corrosion resistant to process fluid and ambient atmosphere.
Adjustment: Independent for span and zero. (Adjustment may be via bus or hand held calibrator)	

IA3.4.4 Temperature Transmitter

Transmitter shall be electronic type for thermocouple or RTD connection.

Transmitter shall meet the following minimum requirements:

Accuracy:	0, 5% of span or better
Repeatability:	0,1% of span
Dead band:	Not to exceed 0,1% of span
Ambient temperature effect:	Not to exceed 0,5% of maximum span per 10°C change
Proof Pressure:	200% of max. process static pressure
Mounting:	Head mounted unless specifically stated otherwise in instrument specification
Material:	Case, primary element and wetted parts shall be made of material that is corrosion resistant to process fluid and ambient atmosphere.
Adjustment: Independent for span and zero. (Adjustment may be via bus or hand held calibrator)	

IA3.4.5 Capacitance Level Transmitter

Transmitter shall be indicating, two-wire electronic type for rod – or rope-probe connection.

Transmitter shall meet the following minimum requirements:

Accuracy:	1% of span or better
Repeatability:	0,2% of span
Dead band:	Not to exceed 0,2% of span
Ambient temperature effect:	Not to exceed 0,5% of maximum span per 10°C change.
Material:	Standard materials that are suitable for process and ambient conditions shall be used.

Probes:	Shall generally be stainless steel / Teflon coated.
Adjustment:	Independent for span and zero.

IA3.4.6 Ultrasonic Level Transmitter

Ultrasonic level measuring device shall have facilities to compensate echo changes due to temperature changes and to ignore periodically recurring false echo due to agitators.

Evaluating device shall be indicating, two-wire electronic type.

Transmitter shall meet the following minimum requirements:

Accuracy:	1% of span or better
Repeatability:	0,2% of span
Dead band:	Not to exceed 0,2% of span
Ambient temperature effect:	Not to exceed 0,5% of maximum span per 10°C change.
Material:	Standard materials that are suitable for process and ambient conditions shall be used.
Adjustment:	Independent for span and zero. (Adjustment may be via bus or hand held calibrator)

IA3.4.7 Radar Level

Microwave level measurement. Measures the transit time of a radar signal that is reflected from the surface of a liquid.

Transmitter shall meet the following minimum requirements:

Accuracy:	1% of span or better
Repeatability:	0.2% of span
Temperature Drift:	<100ppm / °K
Material:	wetted parts stainless steel

Device shall be 2 wire, with a local indication.

IA3.4.8 Guided Radar Level

Guided radar (TOR) level transmitter. Guided radar is based on time domain reflectometry principle. Low power microwaves are sent along conductors and at the point where the waves meet the product surface the waves are reflected.

Transmitter shall meet the following minimum requirements:

Accuracy:	1% of span or better
Repeatability:	0.2% of span
Temperature Drift:	<100ppm / °K
Material:	rod or cable – stainless steel

Device shall be 2 wire, with local indication.

IA3.4.9 Weight Transmitter

Weight transmitters shall be selected in conjunction with load cells, shall have high immunity to plant vibration, allow long distances to load cells and shall be designed to compensate for temperature effects.

Transmitter shall meet the following minimum requirements:

Accuracy:	0,5% of span or better
Dead band:	Not to exceed 0,1% of span
Ambient temperature effect:	Not to exceed 0,5% of maximum span per 10°C change.
Material:	Case, primary element and wetted parts shall be made of material that is corrosion resistant to process fluid and ambient atmosphere.
Adjustment: Independent for span and zero.	(Adjustment may be via bus or hand held calibrator)

IA3.4.10 Open Channel Flow Transmitter

Open Channel Flow ultrasonic measuring device shall have facilities to compensate echo changes due to temperature changes and to ignore periodically recurring false echoes due to agitator.

Evaluating device shall be indicating, two-wire electronic type.

Transmitter shall meet the following minimum requirements:

Accuracy:	1% of span or better
Repeatability:	0,2% of span
Dead band:	Not to exceed 0,2% of span
Ambient temperature effect:	Not to exceed 0,5% of maximum span per 10°C change.
Material:	Case, primary element and wetted parts shall be made of material that is corrosion resistant to process fluid and ambient atmosphere.
Adjustment: Independent for span and zero.	(Adjustment may be via bus or hand held calibrator)

IA3.5 **Converter Design**

IA3.5.1 Electric-Pneumatic Converter (I/P)

Electric to pneumatic converters are intended primarily for use in conjunction with controllers having electrical output or with electrical transmitter where the final control element is actuated from pneumatic actuator or controller.

Pneumatic-electric converter shall be of force balance type and shall convert the direct current input into a standard pneumatic output signal.

Converter shall be provided with a 1:1 relay wherever required in order to provide large volume of air required for rapid operation at long distance.

Transmitter shall meet the following minimum requirements:

Accuracy:	0,5% of span or better
Linearity:	0,1% of span
Hysteresis:	0.2% of span
Ambient temperature effect:	Not to exceed 0,5% of maximum span per 10°C change.
Adjustment:	Independent for span and zero.
Mounting:	Universal bracket suitable for horizontal or vertical support
Case:	Dust-tight for general application

IA3.6 Primary Element Design

IA3.6.1 Orifice Plate Design

Orifice plates shall be made of suitable grade stainless steel, unless process conditions require some other material.

In general, orifice plates shall be designed for flange taps, however, Venacontracta taps may be substituted when designated by good engineering practice.

Concentric type orifices are preferential.

Eccentric or segmented types shall be used for measurement of dirty gases or fluids carrying suspended matter which might tend to cause build-up.

The orifice ratio (orifice inside diameter to process pipe line internal diameter) shall, in general, be between 0,3 and 0,7 for metering accuracy.

IA3.6.2 Annubar Design

Annubar material shall be made of suitable grade stainless steel, unless process conditions require some other material.

In general, Annubars shall be designed for single support and on-line vertical, or horizontal taps.

Opposite side support are to be used only in extreme diameter and high flow cases.

On-line steam purge accessories are to be included for measurement of dirty gases or fluids carrying suspended matter which might tend to cause build-up.

Flow turndown of 10:1 is acceptable.

Annubar element shall meet the following minimum requirements:

Accuracy:	1,0% of actual value
Repeatability:	0,1% of actual value
Mounting:	Universal bracket suitable for horizontal or vertical support

IA3.6.3 Pressure Elements

Directly connected instruments shall be diaphragm, Borden or bellow type elements depending upon the service requirements.

In general, diaphragm elements shall be used in the range of 0 to 100kPa vacuum or pressure, bellow type element for range of 0 to 1000 kPa and Borden tube element for range higher than 1000 kPa.

Primary element material shall be corrosion resistant to process fluid or chemical seals must be provided for protection.

Primary element material shall provide good creep and fatigue resistance, and low hysteresis.

Proof pressure shall be at least twice the maximum system pressure.

IA3.6.4 Temperature Elements

The primary elements for temperature services shall consist of resistance thermometers or thermocouples or radiation pyrometers, depending upon the range of measurement.

The following types of elements shall be used for stated ranges:

Type	Temperature Range °C
Pt-Rh (10%) Pt	0 - 1500 Type S
Chromel – Alumel	0 – 1100 type K
Copper resistance Element	-50 to +100
Platinum resistance Element Pt100	0 to +600

Whenever specified, duplex thermocouple shall be provided.

Thermocouple/emf calibration shall conform to the International Practical Temperature Scale of 1968 (IPTS).

Gas-tight mineral insulated type, reinforced with stainless steel protective tubes shall be used for thermocouples. Preferred outside diameter shall be 6mm. Lengths to fit standardised thermo-wells shall be use.

Resistance thermometer shall be of three lead connection system to the instrument and shall be gas-tight internal insulated type, reinforced with stainless steel protective tubes shall be used for thermocouples. Preferred outside diameter shall be 6mm. Lengths to fit standardised thermo-wells shall be used.

The resistance/temperature relationship shall conform to British Standard 1904 Table 1, 1979 revision or with DIN 43760.

Thermo-wells shall be used for all temperature elements under pressure application. Construction material for thermo-wells shall be suitable stainless steel, unless some other material is required due to process conditions.

IA3.6.5 Radiation Pyrometers

Radiation pyrometers shall be used when:

- Temperatures are above practical operating range of thermocouple.
- Environment will contaminate or seriously limit the life of thermocouples.
- The target is not easily accessible.
- Where plant requirements make them impractical.

Radiation pyrometers shall be of solid state circuitry type and shall, for standard application, respond to 98% of target temperature changes within 2 seconds.

The burner flame detector applications, radiation pyrometers shall be designed for use with self-checking flame self-guard controls.

IA3.6.6 Filled Systems

Filled systems shall not be used unless otherwise specified.

IA3.7 **Indicator Design**

IA3.7.1 Flow Indicators

Flow indicator shall be rotameter or differential pressure type.

Rotameters, when used, shall preferably be of metal type with magnetic indicator extension. Glass type rotameters shall be used for purge or auxiliary services.

Differential pressure type, when used, shall in general be of dry type complete with equalising valve manifold.

Indicators shall have suitable body material and packing of process fluid being monitored.

Scales shall be linear or square root direct reading.

Accuracy shall be 1% of full scale or better and repeatability at least 0,255 of full scale range.

Proof pressure shall be at least 200% of maximum static process pressure at maximum process fluid temperature.

IA3.7.2 Pressure Indicators

Pressure gauges shall generally be 150mm diameter. Case and movement – stainless steel.

Scales shall be white with black lettering. Accuracy shall be 1% of full scale range or better.

Scale ranges shall be selected so that normal process pressure is approximately 50% of full scale.

Rotary geared stainless steel movements shall be used.

Gauges for steam service shall be connected with pigtail siphon. Dampers shall be provided for all pulsating fluids.

Draft gauges shall be diaphragm type or fluid filled manometers.

IA3.7.3 Temperature Indicators

Temperature indicators shall generally be 100mm dial, bi-metallic or fluid type with thermo-well suitable for application.

Material of construction for thermo-well shall be suitable stainless steel, unless some other material is required due to process conditions.

Fluid filled type indicators, when used, shall be either rigid stem or capillary tubing type.

Capillary tubing shall be armour protected.

Stem or bulb shall be suitable stainless steel with welded joints.

Indicator shall be provided with automatic ambient temperature compensation.

Accuracy shall be 1% of full scale range or better.

IA3.7.4 Level Indicators

Sight level glasses or dial type or float type level indicators shall be used.

Each sight glass shall be complete with a pair of offset valves, valves shall have union level connection, flanged tank connection, vent and drain plugs.

If float type indicators are used, cable must be made of braided stainless steel.

Dial type indicator shall be of differential pressure type having accuracy of 1% of full scale or better.

IA3.8 Switches and Controllers

IA3.8.1 Mechanical Switches

Pressure, flow level, temperature etc. type switches shall be provided with enclosures of a type to suit individual area environment.

Actuating switches shall be either hermetically sealed mercury type or snap action micro-switches. Contacts shall have a minimum rating of 2 inductive braking at 220V AC.

All switches shall have two parallel contacts normally open/closed and the on-off differential switches shall be adjustable. Adjustable range shall be suitable for switch application, actuation set point shall be adjustable over full scale range.

All switches shall have an accuracy of 1% or better of full scale range.

Level switches shall be in general resonating or displacer type. Standard material shall be suitable for process and ambient conditions. Material of the displacer shall be stainless steel.

Conductivity level switches shall be either single or double type with contacts changeable to minimum/maximum closed safety circuit. Electrodes shall be heavy version, either single or three rod types, material shall be preferable of special steel.

Position switches shall be of inductance or capacitance proximity sensors with single or dual potential free contacts.

IA3.9 Actuators

IA3.9.1 General

Actuators shall be either pneumatic diaphragm or pneumatic piston type.

All actuators shall have a stall torque rating of at least 150% of maximum required torque for the driven element.

All actuators shall have a minimum repeatability of 0,5% of full travel. Hysteresis effect shall not exceed 1,0% of full scale travel.

Manual over-ride facilities shall be provided.

A mechanical shaft position indicator shall be standard on all actuators.

Actuators shall have a totally enclosed housing to provide complete protection for all moving, pneumatic and electronic parts. Construction material shall be suitable for ambient and process conditions.

Unless specified otherwise, actuators be of spring return type for fail-safe operation.

IA3.9.2 Pneumatic Actuators

Actuators shall be of diaphragm or cylinder type for either rotary or linear version depending upon specific application and shall be reversible for air-to-open or air-to-close action.

Actuator shall operate on 600 kPa, cylinder shall be able to withstand a line pressure of 1500kPa. Positioner shall operate on 20 to 100 kPa.

Corrosion, endangered parts such as cylinder wall, piston rod, torque plug, etc. shall be manufactured of hard wearing and rustless metal, with high lubricity.

Actuators shall be provided complete with line filter, lubricator, positioner, manual operating handle and air lock-up system, unless otherwise specified.

For actuator position remote indication the provision for two limit switches attachment shall be provided.

IA3.9.3 Electric Actuators

Actuators shall be fitted with a 3 phase 400 squirrel-cage motor.

If two speeds are required a pole-changeable motor may be used.

Output force of the motor shall be transmitted through a stage of spur gears, a spring-balanced worm with axial bearings, a worm wheel, and a clutch stage to the output shaft.

All actuators shall be fitted with a double torque-dependent switch.

For remote position indication of actuators fitted to modulating valves, provision for an analogue 4-20 mA attachment shall be provided. For isolation valves two limit switches shall be provided. All actuators must be able to communicate via Modbus TCP/IP

Provision for manual operation shall be made by means of a hand wheel – the mechanically independent hand-wheel shall be engaged by means of a clutch, which also de-clutches the motor drive from the output shaft.

Actuators shall be fitted with a mechanical position indicator.

Technical specifications:

Torque and travel dependent switches:

NO, NC or change-over:	10A at 30V AC, 5A at 250V AC 5A at 30V DC, 0,4V at 250V DC
Mechanical life time:	$\pm 10^6$ cycles
Suitable for ambient temperature	-20 to +80°C
Electronic position indicator:	
Supply voltage:	15 to 30V smoothed
Output:	4-20 mA load R: 500 ohm at 15V, 1250 ohm max. at 30V
Current consumption:	Max. 40 mA at 20 mA output signal
Linearity deviation:	$\pm 1\%$ from 5 to 95% of measuring range
Suitable for ambient temperature	-25 to +90°C
Adjustment:	Independent for span or better
Linearity:	0,1% of span
Hysteresis:	0,2% of span
Accuracy:	0,5% of span or better
Case:	Dust-tight for general application

IA3.9.4 Control Valves – General

Control valves for modulation services shall be pneumatically operated.

Flange facing and drilling shall be according to either BS or equivalent DIN standard.

Control valves of size 40mm and above shall have flanged end connections.

In general control valves of size 40mm and below shall have screwed connection.

Valve size shall be based on specified allowable pressure drop at 130% of normal process design flow conditions.

Valve top-works shall be sized so that the valve will operate properly when upstream pressure is 10% above maximum inlet pressure and downstream pressure is atmospheric.

Isolating valves and by-pass valves shall in general be provided for each control valve application. Isolating valves shall be of line size whereas by-pass valves shall be of control valve size.

Seals and liner material used for valves in boiler gas lines shall be made of VITON.

Nylon shall not be used unless otherwise specified.

Close attention shall be given to the selection of valve body, line and diaphragm material depending upon specific application, however, Engineer approval is required prior to order.

IA3.9.5 Diaphragm Valves

Diaphragm valves shall be used where process control quality requirements are comparatively poor and a low pressure drop across the valve is required or where the valve function is restricted to on-off control

Diaphragm valves shall be used for aggressive fluids such as weak sulphuric acid, corrosive, slurry and sludge which contain solids in suspension.

For application with high control frequency another valve type shall be considered.

Material construction:

Body:	Cast Iron
Liner:	Hard rubber, Soft rubber, Butyl
Diaphragm:	Depending on application.

IA3.9.6 Globe Valves

Globe valves shall be used in the majority for conventional control application.

For water, steam, gas and air control applications, a cast steel valve body with stainless steel trim shall be provided.

In case of special treated water, selection of stainless steel body may become necessary.

For oxygen control application, a bronze valve body with monel-metal trim and a PTFE Chevron packing shall be provided.

Trim material shall normally be of 316 stainless steel, for special applications stellite shall be used.

Extended bonnets and graphite laminate/filament packing shall be used for operating temperature higher than 200°C up to 530°C.

IA3.9.7 Butterfly Valves

Butterfly valves may be used for modulating service but shall not be used for shut-off service if the maximum differential pressure across the valve exceed 500 kPa.

Butterfly valves shall be used for high control performance and where low process pressure loss with high recovery is required.

For water, gas and air application, a cast steel valve body with stainless steel disk shall be provided. Packing shall be of PTFE Chevron up to 100°C and graphite laminate/filament packing for high temperatures. In case of special treated water, selection of a stainless steel body may become necessary.

For acid application polypropylene valves shall be provided.

Close attention shall be paid to the selection of valve body, disk and packing material depending upon specific application; however, Engineer approval is required prior to order.

IA3.9.8 Ball Valves

Ball valves shall be used for modulating and shut-off service where high control performance with low process loss and high recovery as well as tight shut-off function is required.

For water, gas and air application, a stainless steel valve body with stainless steel disk shall be provided. Packing shall be of PTFE Chevron up to 100°C and graphite laminate/filament packing for higher temperatures.

IA3.10 **Analytical Instruments**

IA3.10.1 General

Instruments measuring pH-value, Dissolved Oxygen, Conductivity, Concentration or other properties of process streams shall consist of a suitable design primary element to convert or transform the measured variable into an electrical signal which shall be fed to a control system.

Analyser shall be capable of operating under the ambient conditions prevalent in the specific plant area and to maintain calibration within 0,5% during a 24-hour period while subject to temperature variations between 10°C and 50°C.

Analysis time shall not exceed 30 seconds.

Reproducibility of analysers shall be 1% of span or better and sensitivity shall be 0,5% of full span.

For calibration purposes, analysers shall be provided with one year supply of a certified calibration sample as well as calibration curves.

All necessary accessories including nozzles, valves and fittings shall be provided. For high temperature applications, sample coolers shall be provided. Sampling accessories shall be of material suitable for each specific application.

IA3.10.2 pH Measurement

For pH-measurement, reference electrode shall be of rugged and sealed construction moulded in glass coupled polypropylene. Electrical connection shall be made directly onto the outer end of the element ensuring first class electrical performance of the electrode.

Measuring pH-electrode shall be of toughened all purpose glass type giving accurate Ph reading with long electrode life.

In applications where variations in sample temperature may occur, automatic temperature compensation device shall be provided.

The reference and glass electrode including the automatic temperature compensator shall be housed in a compact sensor holder assembly provided with terminal block, cable glands, silica-gel desiccator and screened top cap to prevent against spurious pick-up.

Electrodes assembly materials shall be of glass couples polypropylene and the assembly shall be provided with either flow through type or immersion type, depending upon specific application, complete with all associated accessories and mounting bracket.

pH-transmitter shall be electronic two wire type, with alphanumeric operator interface, manual and automatic calibration facilities, and shall meet the following minimum requirements:

Accuracy:	0,5% of span or better
Measuring range:	0-14 pH
Temperature Compensation:	Glass electrode 0° to 130°C
Cycle:	max. 1,5 seconds
Output:	Preferable 4 to 20 mA DC
Relay Output:	Alarm contact 220 V AC 5A NC
Mounting:	Universal type bracket

IA3.10.3 Conductivity Measurement

Cell electrode material shall be carbide lined high grade steel or platinum black coated nickel and the cell range shall be selected to suit the required measurement.

Cell shall be equipped with semiconductor temperature sensor for temperature compensation.

Cell shall be either of flow through type or immersion type, depending upon specific application, complete with all associated accessories and mounting bracket.

Conductivity transmitter shall be electronic two wire type, with alphanumeric operator interface, manual and automatic calibration facilities, and shall meet the following minimum requirements;

Accuracy:	2% of span or better
Measuring range:	0,1 to 100 µS/cm depending on used cell type
Reproducibility:	1% within range or better
Temperature Compensation:	Semi conductor 0° to 130°C
Cycle:	max. 1,5 seconds
Output:	Preferable 4 to 20 mA DC
Relay Output:	Alarm contact 220 V AC 5A NC
Mounting:	Universal type bracket

IA3.10.4 Oxygen in Combustion Measurement

Cell electrode material shall be of Zirconia.

Cell shall be equipped with semiconductor temperature sensor for temperature compensation.

Cell shall be direct insertion type, complete with all associated accessories and mounting brackets.

Oxygen analyser transmitter shall be electronic four wire type, with alphanumeric operator interface, manual and automatic calibration facilities, and shall meet the following minimum requirement:

Accuracy:	1,0% of span or better
Measuring range:	0 to 5, 0 to 10 or 0 to 20 vol % O ₂
Reproducibility:	1% within range or better
Temperature Compensation:	0° to 1400°C
Response rate:	90% response within 5 sec when gas introduced from calibration gas inlet
Warm up time:	max. 15 minutes
Output:	Preferable 4 to 20 mA DC
Relay Output:	Alarm contact 220 V AC 5A NC
Mounting:	Universal type bracket
Calibration:	One-touch calibration using calibrated memory

IA3.10.5 Dissolved Oxygen Measurement

The measuring sensor shall be of the Luminescent type – LDO technology.

The sensor shall be equipped with a hermetically sealed cable suitable for direct immersion. The cable end shall be fitted with a quick disconnect plug.

The sensor shall be mounted on a manufactured extension bracket for immersion in an open tank application to allow easy access for cleaning purposes.

The DO transmitter shall be electronic four wire type, with alphanumeric operator interface, manual and automatic calibration facilities, and shall meet the following minimum requirements:

Accuracy:	0,2% of span or better
Measuring range:	0-20.0 ppm or 0-20 mg/L
Temperature Range	0 to 50°C
Response time:	90% in less than 40 sec.
Power Supply:	220 V AC
Output:	4 to 20 mA DC
Mounting:	Universal type bracket

IA3.10.6 Turbidity Measurement

The measuring sensor shall be of the self cleaning type with wiper blade

The sensor shall be equipped with a hermetically sealed cable suitable for direct immersion.

The cable end shall be fitted with a quick disconnect plug.

The sensor shall be mounted on a manufactured extension bracket for immersion in an open tank application for ease of maintenance.

The Turbidity transmitter shall be electronic four wire type, with alphanumeric operator interface, manual and automatic calibration facilities, and shall meet the following minimum requirements:

Accuracy:	0.001 NTU
Measuring range:	0.001 – 4000 NTU

Temperature Range	0 to 50°C
Power Supply:	220 V AC
Output:	4 to 20 mA DC
Mounting:	Universal type bracket

IA3.10.7 Suspended Solids Measurement

The measuring sensor shall be of the self cleaning type with wiper blade

The sensor shall be equipped with a hermetically sealed cable suitable for direct immersion.

The cable end shall be fitted with a quick disconnect plug.

The sensor shall be mounted on a manufactured extension bracket for immersion in an open tank application for ease of maintenance.

The Suspended Solids transmitter shall be electronic four wire type, with alphanumeric operator interface, manual and automatic calibration facilities, and shall meet the following minimum requirements:

Accuracy:	< 5% of reading
Measuring range:	0.001 – 50 mg/l
Temperature Range	0 to 50°C
Power Supply:	220 V AC
Output:	4 to 20 mA DC
Mounting:	Universal type bracket

IA3.10.8 Tank or Hopper Mass Measurement

If mass content measurement of a vessel is required, the vessel shall be supported on load cells.

The mechanical design shall make provision for load cell protection against overload, shock load and plant vibration. It shall also take into consideration the prevention of excessive shear loads being transmitted to the load cell without affecting the accuracy of the scale.

Jacking facilities shall be provided to enable the load cell to be removed without taking the vessel out of service.

Copper braiding shall be connected across load cells to protect them against welding currents.

Continuous weight monitoring shall be achieved by the load cells weight detectors, weight transmitters and suitable indicators. An electrical signal, preferable 4 to 20 mA, shall be provided to be fed to a control system.

Load cells shall be of robust hermetically sealed stainless steel construction and shall meet the following minimum requirements:

Temperature Compensation:	0 to 55°C
Temperature Effect:	Not to exceed 0,5% of maximum span per 10°C change
Accuracy:	0,5% or better
Overload:	200% of nominal load
Rated Output:	1mV/V

Load cell cable joints are to be soldered according to manufacturer's instruction.

IA3.11 Instrument Panels And Cabinets

IA3.11.1 Construction

Panels shall be free standing type and shall be fabricated from cold rolled sheet steel of thickness not less than 2mm with welded construction throughout. All welds shall be ground smooth, all corners to be ground and all weld spatters shall be cleaned.

Surface of panels shall be painted and free from all marks and defects.

Mounting angle, flush with bottom of panel, shall be provided. All panels shall be supported on suitable sized vibration isolators, designed for bolting to panel frame and flooring.

Accessories such as swing rack mounting frames, circuit breaker panels and covers, base gland plates, etc, shall be standardised.

Front doors shall be fitted with suitable armoured glass cut-out and rubber gasket and shall be hinged door lockable. Rear doors shall be of solid construction and lockable.

All instrument cut-outs and drillings shall be straight and true. If provisions are to be made for further instrument installation, cut-outs shall be made and suitable blanks shall be provided. Blanks shall be painted with same colour as panel and a minimum of four anchors shall be used to attach them to panel board.

Instruments mounted on panels shall be spaced to provide access for adjustment and removal of equipment.

Removable eye bolt lifting lugs shall be furnished and installed on all panels.

IA3.11.2 Field Junction Boxes

Boxes shall be constructed of 304SS and painted with hinged and lockable door. Mounting plate and bottom gland plate suitable for electric and pneumatic process connection shall be standardised.

All instrument cut outs and drillings shall be straight and true. If provisions are to be made for further instrument installation, cut outs shall be made and suitable blanks shall be provided.

Instruments mounted on boxes shall be spaced to provide access for adjustments and removal of equipment.

The degree of protection shall comply with IP 65. Construction material shall be suitable to resist the conditions prevalent in the specific plant area.

Field boxes are to be fitted with knife type termination, indicating fuse holders are to be used where power is supplied to solenoids or any other secondary field instrument.

All cables should be properly glanded and all cores will be terminated PLC connections are to be terminated at the left and field connections terminated at right.

All terminals to display an identification number according to the numbering standard as applied.

The panel wires should be as per table below

Wire	Colours
220/110 volt AC control : Orange	Orange
AC neutral wires : Black	Black
24-50 volt AC control : Red	Red
24-50 volt AC neutral : Pink	Pink

24-50 volt DC control : Purple	Purple
Zero volts DC : Blue	Blue
PLC wiring : Gray	Gray
Telemetry wiring : Yellow	Yellow
Earth wires : Green yellow	Green Yellow
CT's to ammeters : White	White

IA4 Process Instrumentation Installation Specification

IA4.1 Quality Assurance

IA4.1.1 Codes and Standards

The process instrumentation supplied shall comply fully with the applicable SANS/IEC/IEEE specifications as set out in the table below and all equipment shall bear the mark of approval of the South African Bureau of Standards. The latest issue of the SANS/IEC/IEEE/ NRS codes will be applicable.

SANS 10142-1 : National Standards for the wiring of premises
SANS 1507 : Electric Cables (300/500V to 900/3300V)
SANS 1574 : Electric Cables Flexible cords and flexible cables
SANS 1411 : Material of insulated electric cables and flexible cords
SANS 1803-1 : Lugs and ferrules for insulated cables
SANS 60793 : Optical fibres
SANS 60794 : Optical fibre cables
ISO/IEC 14763-3 : Fibre optic testing
EN 50288 : Multi-element metallic cables used in analogue and digital communications and control
ISO/IEC SANS 11801:2002 : Information Technology – Generic cabling for customer premises
SANS 1091:2004 : National Colour Standard.
SANS 1274-2005 : Coatings applied by the powder-coating process.
SANS 1186 : Information and Safety Signs.

IA4.2 Introduction

This standard specification furnishes information and sets out requirements for the installation of instrumentation equipment.

All equipment and material shall be of a quality and type approved by the Engineer.

No equipment or material shall be installed unless it complies with the requirements of this specification.

All equipment and material shall be checked for suitability, quality and adherence to this specification. Every approval must be obtained by the Contractor prior to installation.

Any installation or installation procedure which is in contravention to this specification shall be made good or replaced, to the satisfaction of the Engineer, and all costs for making good or replacement shall be for the contractors account.

Failure to adhere to the requirements of this specification may result in the equipment or material being rejected by the Engineer.

IA4.3 Standard of Work

The complete instrumentation installation shall be carried out by skilled, competent and qualified operatives to the highest standard of safety and workmanship, using the correct tools for the operations and best quality materials.

A clean, orderly and safe environment shall be maintained in the Instrumentation Contractor's workshop, the stores and offices and in the construction areas.

Cabling and wiring shall form a neat and functional appearance.

Work shall be planned such that access to equipment for the current installation or future maintenance shall not be obstructed.

The completed installation including supports, brackets, wiring, cabling and piping shall present a clean, tidy appearance and shall conform to good engineering practice.

The contractor shall install instruments and other equipment in accordance with the manufacturers instructions, and the project drawings, taking due cognisance of the Standards and Codes listed in this Specification.

The standards and codes which shall apply to this project are those issued by the following organisations:

- British Standard Institution (BSI)
- Deutsche Industrie Normen (DIN)
- American National Standards Institute (ANSI)
- The Instrumentation, Systems and Automation Society (ISA)
- South African Bureau of Standards (SABS)

IA4.4 Instrument Locations

General locations of the instruments are shown on the instrument location drawing. It may however be necessary to make minor changes on site. In the interests of the prevention of rework, confirmation of the exact location shall be obtained by the contractor from the site representative before the work is carried out.

Where no instrument location drawing is available the instrument shall be positioned as close as possible to the process monitoring point.

The instrument shall be mounted in an easily accessible position to facilitate maintenance and removal.

The contractor shall avoid, where possible, locating instruments in locations subject to leaks and spills. Where an instrument is unavoidably located where exposure to the above mentioned is likely, a splash guard shall be provided over or around the instrument.

Field mounted instruments, excluding in-line and close-coupled devices shall be mounted so that the centre line of the housing, chart or scale is approximately 1,400mm above grade, floor or platform, unless otherwise specified on an installation drawing.

Instruments must not be mounted where there is excessive vibration.

Instruments must be mounted away from steam lines and other sources of heat.

Instruments are not to be mounted on hand rails or process parts of the plant (e.g. pipe lines).

Transmitters or local controllers shall be located as close to the primary process connection as possible but instrument accessibility must be maintained.

Instruments shall be installed so as not to cause any obstruction to walkways, headroom or access to other plant items.

Instruments are not to be mounted near or in the way of sections of the plant that are regularly removed.

Direct mounted dial thermometers, pressure switches, pressure gauges and thermo wells shall be plainly visible and accessible from floor or adjacent platform.

IA4.5 Supporting Bracketing and Fixing

The drilling of holes in structural steelwork is not permitted except with the prior written approval of the engineer.

The drilling of holes in vessels or pipe work is expressly prohibited.

Explosive type fixing devices shall not be used.

Instrument pipe stands where required are to be manufactured according to the drawings. All stands should be floor mounted unless otherwise stated. Fixing bolts, nuts and washers must not be cadmium plated. They shall be hot dipped galvanised or stainless steel.

Mounting brackets must be hot dipped galvanised.

Instrument supports and mounting brackets shall be of a suitable strength and rigidity to ensure proper operation of the instrument. Careful attention shall be given to ensure that instruments are not mounted on or attached to equipment or structures which are subject to vibration. All proposed locations must be approved by the Engineer before installation.

Brackets shall in general, be made of mild steel flat bar, angle or channel. All brackets shall be hot dipped galvanised.

IA4.6 Instrument Piping and Tubing

The instrument primary process connection is defined as the connection after the first isolation valve on the process pipeline, duct, vessel, or tank. The isolation valve will be supplied and installed by others unless specifically stated otherwise in the instrument installation/wiring diagram.

Piping from the primary process connection to the instrument shall be as short as possible and shall be installed so that no pockets or traps can occur. Where such pockets are unavoidable, drain valves and pots shall be provided at the lowest points. All such piping shall be properly supported to relieve all connections points of strain, and where expansion is likely, suitable offsets should be incorporated.

Instrument piping impulse lines shall be 12mm seamless stainless steel, except in specific high pressure temperature applications where the process conditions will dictate the material. Process connection tubing shall be 12mm seamless stainless steel and 10mm or 6mm seamless stainless steel for signal lines, depending on application.

Air supply manifolds are to be made of stainless steel. Drain valves must be fitted to the lowest point of the manifold. Each take-off point must have an isolation ball valve. Each take-off point shall be labelled with the instrument reference number. An allowance must be made for 20% spare take-off points. All take-off points not utilised must be plugged after the isolation valve.

Air supply tubing from manifolds to air regulators or solenoid operated valves shall be 12mm seamless stainless steel.

Air supply tubing from regulators and solenoid operated valves to actuators, positioners, etc. shall be 10mm seamless stainless steel.

All tubing fittings shall be Gyrolok, or an approved equivalent.

Isolation valves, other than those intended for use with an orifice carrier, are not normally the responsibility of the instrument section, but are supplied as part of the plant pipe work.

Valves shall be accessible for operation from floor and operating platforms unless otherwise approved by the Employer. Valves or equipment shall not obstruct passageways.

All instrument piping entering or leaving a control cubicle, box or panel shall do so via a bulkhead coupling.

In cases where pipe penetration openings are not provided in gratings which are installed by others, openings shall be field cut and the grating banded. The contractor shall then paint the cuts and welds according to the paint specification. This must be avoided at all times where possible.

Capillary tubing for filled system temperature instruments, diaphragm level transmitters and the like, shall be supported and protected by running the tubing in angle iron or 'Unistrut' channel for the entire exposed length of the capillary. Excess capillary tube shall be neatly coiled and secured. Minimum bend radius for capillary tube shall be 75mm.

Piping within plant building shall be carried on overhead racks attached to the building frame or other supports. Piping racks shall be separate from cable racks. Existing piping racks may be used after permission is obtained from the Engineer.

Every pipe installed on racking in a building or on a supporting structure shall be supported in such a manner that there is no undue mechanical strain on any termination.

IA4.7 Cable Racks and Support

Cable rack/tray shall follow the building or mechanical construction line to which they are attached, with as few direction changes as possible.

Cable racks shall be mounted in the vertical plane and shall be positioned so as to avoid obstruction to walkways and access routes. Racks shall not be mounted in the horizontal position without the prior written permission of the Engineer.

Cable rack/tray bends and tees will be constructed as to allow all cables within trays to have a bending radii of not more than the manufacturer's specifications. No right angle jointing of rack/tray will be allowed.

Cable rack/trays shall be properly aligned and supported and the completed installation should have no visible deflection and be devoid of any distortion, kinks or sags.

The maximum distance between centres of adjacent supports shall be 2 metres. Additional supports shall be located at the joints of straight tray lengths and at every change in direction.

Supports shall be attached to permanent members of the building.

Cable racks to be fabricated mild steel and hot dipped galvanised similar or equal to the 'O' line support system unless specified otherwise in the document

Touching up after fabrication shall be by cold galvanising.

Single angle cable supports may be used under the following conditions:

- Up to no more than 3 cables may be run on an angle iron support
- The size of the angle iron shall be such that in cross section, no part of any cable shall project beyond the square of which the angle iron forms two sides
- The minimum size angle iron to be used shall be 25 x 25 x 5mm and maximum size 40 x 40 x 6mm

Where required, any cable in danger of mechanical damage will be protected by using galvanised pipe or channel.

Cable rack/trays shall be installed in accordance with the route diagram. Minor deviations in routing to avoid interference may be allowed subject to the approval of the Engineer. Where no cable routing drawing is available the cable routes shall be "site" determined in conjunction with the Engineer.

All cables run on racking or angle iron supports shall be fully supported to within 150mm from the gland entry on the equipment serviced or as cable size dictates.

IA4.8 Cabling and Wiring

Cable sizes, number of cores and cable number shall be as indicated on the cable schedules.

Cables shall be tested per drum length on delivery to site prior to installation. Results shall be documented.

Cable drums shall be rolled in the proper direction to prevent loosening of the cable. Cable shall be drawn into position using a sufficiency of rollers and cornering apparatus to avoid damaging the cable by excessive bending or dragging.

Cable shall be stored in dry areas.

Where cables pass through a floor, they shall be protected by a metal pipe or suitable mechanical protection, extending from 50mm to 350mm above floor or ground level.

The contractor shall observe the manufacturer's recommendations for minimum bending radius but shall never use less than the following radii:

- Unarmoured cables: 5 times the overall outside diameter of the cable
- Armoured cables: 10 times the overall outside diameter of the cable

Clips, saddles or clamps for securing of cables shall have smooth and rounded edges and shall not damage the cable sheath or serving. The type of saddle or clamps shall be approved by the Engineer before installation commences.

Instrument signal and electric power may not run bunched in the same rack/tray. A minimum distance of 300mm shall separate such racks/trays. If instrument cables are required to run on the same cable rack as electrical cables, then there must be at least a 300mm gap between the electric and instrument cables.

To avoid interference arising from electrical power supply voltage dips or spikes, instrument signals and electrical power cables shall only cross at right angle to each other.

On no account will instrument signal and electrical power wiring be transmitted in the same multi-core cable. Solenoid coils of 24V or less may be run with instrument switching signals.

Instrumentation cables may only be installed a maximum of 2 deep on racks if approved by the Engineer.

Joints in cables are permitted only where the length of the run exceeds the standard manufactured length of cable available on a drum. In these cases, the joints will be made in a junction box. No through jointing of cables will be permitted on cable racks/trays or in any cable way.

Coaxial cable for data highways shall be run individually in 20mm conduit as per 7.16. Conduits used for this purpose shall be installed a minimum of 300mm from electrical cables.

All cables shall be labelled at each end and at 10m intervals along its length with a strap on plastic marker tags bearing the cable number as shown on the cable schedule. (Black letters on a yellow background).

All cables shall be mechanically anchored at the position of termination by the use of flanges of the correct size, as follows:

- Where equipment supplied is provided with cable entries having DIN, NPT, etc., threads, the contractor shall provide all necessary adapters to permit the use of standard ISO Metric thread cable glands.
- Where glands are to be used with non-threaded clearance holes, a heavy duty lock-bush, together with suitable weatherproofing gaskets shall be provided. Holes with a tolerance greater than 1.5mm larger than the gland size will not be accepted.
- Cables shall always be made off according to the gland manufacturers recommendations.
- When glanding off SWA cables in non-conducting enclosures the gland shall be provided with an internal earthing washer and connected to a suitable earth connection.

Where wiring is specified to be run in conduit, the following shall be observed:

- The conduit used shall be heavy gauge seamless metal conduit with galvanised finish. Flexible conduit shall be of the PVC sheathed variety.

- The conduit shall have a smooth bore. The smallest size to be used shall be 20mm and the largest 50mm nominal diameter.
- All conduit joints and entries shall be screwed a minimum of 20mm and made tight and weatherproof. Conduit threads shall be protected from corrosion by the application of an approved cold galvanising paint.
- Draw-in boxes shall be installed after every second bend or a combination of sets and bends which equal 180 deg. or after every 7,5m of straight run. All boxes shall be supplied with gaskets for weatherproofing.
- Where the possibility of condensation exists, the conduit shall be installed with a slope of approximately 3 in 100 and a 3mm diameter drain hole shall be drilled at the lowest point.
- Metal conduits shall be bonded and earthed. Conduit bends, boxes, flexible conduits, etc., shall not interrupt the earth continuity.
- Conduit must not be used as an earth continuity conductor.
- The minimum bending radius of conduit shall be 6 times the conduit diameter.
- Conduit shall be fixed with clips or saddles at a pitch not exceeding 1,5m.

IA4.9 Cable and Wire Terminations and Connections

All instruments, control panels, junction boxes, etc., shall be wired in accordance with the relevant project drawings.

Each conductor shall be fitted with an insulated double crimp lug of the correct size. Pin lugs shall be used for pressure type terminals. Ring or spade lugs shall be used for post type terminals.

A proprietary type of wire stripper must always be used. The stripping tool must be checked regularly and is subject to inspection by the Engineer. The termination of stranded conductors where one or more strands have been damaged or broken is expressly prohibited.

The crimping tool used for attaching termination lugs shall be of the ratchet type which requires a specific amount of pressure prior to release, recommended by the manufacture of the crimp lugs.

All wires are to be terminated. Spare terminals shall be provided for unused pairs or cores. All spare terminals of field multi-cores shall be connected together and bonded to instrument earth.

Terminated wires shall be arranged neatly and loomed where necessary using cable ties. Spiral lacing shall be used for flexible or semi flexible looms.

Each wire shall be numbered with the respective terminal number by means of interlocking slip-on plastic ferrules of the correct size. Split or clip on ferrules are not acceptable. The ferrules shall be a tight or interference fit on the wire.

Cable colours:

- Normal signal cables - black outer sheath
- Earth cables - green

Conductors to be 0,5mm flexible stranded twisted copper wire for normal instrument signals and 1,5mm to solenoid valves.

Nylon washers shall be put on all cable glands and cable gland adapters on weatherproof boxes.

Cables must not be trapped in lagging.

Cables to field instruments must have at least 30cm slack which should be neatly looped before the instrument.

Cables incorporating shields or screens shall have the shield or screen isolated for electrical earth throughout its length and it shall be earthed only at the point indicated on the drawing.

Only cable in the following standard sizes shall be used:

- | | |
|------------|----------|
| • 1 pair | 1 triad |
| • 2 pairs | 2 triad |
| • 4 pairs | 4 triad |
| • 8 pairs | 8 triad |
| • 12 pairs | 12 triad |
| • 16 pairs | 16 triad |
| • 24 pairs | 24 triad |
| • 36 pairs | |
| • 50 pairs | |

For field instrumentation power supply only 3 core S.W.A. or Dekobon cable shall be used.

The approved cable is Dekobon type M855 single pair, M877 multi pairs and M865, M887 respectively for triads. The conductor size shall be 0,5mm² for instrumentation signals unless specified otherwise in the instrument cable schedule.

A variation from this type of cable must have the permission of the engineer.

Instrument cabling identification

Cables are to be labelled according to the cable schedule. The numbering will be made up as follows:

Field instrument to JB or marshalling:

- analogue = IA + instrument tag number
- digital = ID + instrument tag number
- power = IP + instrument tag number

JB to marshalling:

- marshalling terminal strip number

IA4.10 Junction Boxes

Junction boxes must be numbered on the door or lid with an engraved plastic type label having numbers at least 5mm in height. (Refer section 12 Instrument Labels).

Terminal rails and individual terminals shall be numbered.

An earth plate or rings for the cable glands shall be put in the bottom of each junction box, where required.

Cables must enter from the bottom of the junction box.

Spare holes for cable glands must be plugged with the approved type of plugs.

Boxes with pneumatics inside must have a vent at the bottom of the box and shall be fitted with a port protector/silencer.

Shield wires must be strapped together.

The box must be classified IP65 or better.

The box must be mounted securely.

Junction boxes shall be polycarbonate. Painting or other colouring is not required.

IA4.11 Instrument Installation Specific Requirements

IA4.11.1 Flow Meters

The in-line element of the flow meter will be installed by others. It is the responsibility of the instrumentation contractor to check that the correct element is installed and that it is correctly installed and is undamaged before accepting the installation for his part of the work.

The flowmeter/d.p. cell shall be installed and piped up according to the instrument installation diagram.

Orifice plates shall be clearly stamped with the orifice diameter, direction of flow and tag number.

The minimum slope of lines to instruments situated above or below the primary element shall be 25mm per metre.

If seal-pots are used, they shall be located as close as possible to the orifice taps and shall be installed so that both seal-pots are the same elevation.

DP cells must not be mounted where there is excessive vibration. On steam applications, the measuring element and isolation valves must be below the orifice tapping points.

Magnetic flow meters shall be installed such that the product lines remain full when flow occurs and when flow is zero.

Magnetic flow meters mounted on lined pipes shall have earthing rings mounted on the upstream and downstream flanges. Earth bonding trays shall be installed as per manufactures instructions and/or the instrument installation diagrams.

IA4.11.2 Control Valves

Control valves shall be mounted by others so that the direction of flow indicator (if any) on the valve body is compatible with the direction of flow of process fluid in the pipe. It is the responsibility of the instrumentation contractor to check that the correct valve is installed and that it is correctly installed and there is no damage visible before accepting the valve for hooking up to pneumatics or electrics.

The control valve shall be installed and piped up according to the instrument installation diagram.

A bulkhead plate will be provided where stainless steel/dekabon lines end and flexible lines start.

Flexible lines are to be tidy and are not to be in contact with any hot surface.

The position of the limit switches on a valve should be made adjustable.

IA4.11.3 Level Measuring Instruments

Ultrasonic transducers shall be mounted in such a way that any vibration present at the site of installation cannot be mechanically transmitted to the transducer housing. In this respect, the manufacturer's instructions must be strictly adhered to.

Flange mounted ultrasonic transducers must be mounted on a thick gasket of soft resilient material and lightly secured with PVC or nylon nuts and bolts. Under no circumstances shall the bolts be over tightened, finger tightening is sufficient.

Differential pressure type level transmitters shall be installed onto instrument stands unless they are of the flange mounted type. Connections shall be as per hook-up drawings.

IA4.11.4 Temperature Elements

A thermo well must be inserted first to protect sensor against damage from corrosion, erosion, abrasion and high pressure processes.

The elements used to measure temperatures will be either thermocouples, platinum resistance temperature bulb (R.T.D.) or capillary filled local indicators.

The element must be installed in such a way that it is easily accessible for inspection and replacement.

The tip of the measuring element must reach and be in contract with the end of the thermo well.

Positions of detecting elements shall be such to facilitate easy removal without fouling.

Capillary lines are to be protected.

IA4.11.5 Pressure

All pressure points shall be fitted with ½ inch N.P.T. isolation cocks unless flush mounted diaphragms are used.

If the fluid to be measured is toxic or corrosive, a drain or vent shall be provided to discharge the fluid to a safe location.

Where the pressure pulsates heavily, suitable damping shall be fitted.

Gauges more than 3m from their impulse points shall have an additional isolation valve at the gauge.

If the unit is not flange mounted and the process fluid is dangerous, a valve must be fitted for releasing the pressure in the impulse line.

Gauges shall be mounted in a vertical position.

IA4.11.6 Instrument Labels

Each instrument shall be fitted with a label giving the function and tag number as detailed in the label schedule. Field mounted instruments including final control elements shall have labels mounted on a bracket which is fixed independent of the instrument and stays in position if the instrument is removed. The label must be in a clearly visible location.

Labels shall be made of laminated trafolite and have black letters on a white background.

The size of the labels shall be:

Type 1	Field Instruments/ Transmitters/ Control Valves	80mmW x 30mmH
Type 2	Cabinets/ Field Junction Boxes	200mmW x 30mmH
Type 3	Terminal Rails	39mmW x 18mmH
Type 4	Power Supplies	70mmW x 20mmH
Type 5	Power Rails	15mmW x 10mmH
Type 6	Marshalling Cubicles	150mmW x 50mmH
Type 7	Distribution Boards	150mmW x 50mmH

Type number will be included in the label schedule with the letter size.

IA4.12 **Instrument Numbering**

The instrumentation shall be tagged according to the following system:

Prefix : MCC area code
 Instrument type : Modified ISA abbreviation
 Instrument number : Sequential number e.g. 02-LT-02
 MCC 2, level transmitter, 2nd instrument in that area.

IA4.13 **Cable Numbering**

Cable numbering must be done in line with the figure below, with the four identifiers as shown in the examples:

FIRST IDENTIFIER - (AA)		SECOND IDENTIFIER - (NNN)		THIRD IDENTIFIER - (AAA-NN)		FOURTH IDENTIFIER - (AAA-NN)	
CABLE TYPE CODE		CABLE NUMBER CODE		CABLE SOURCE CODE		CABLE DESTINATION CODE	
Electrical Power	EP	Sequential Cable Number	001 - 999	MCC Number	MCC(01 - 99)	MCC Number	MCC(01 - 99)
Electrical Motor Control	EC			Junction Box Number	JB(01 - 99)	Junction Box Number	JB(01 - 99)
Instrumentation signal	I			Instrument Tag Number (Third & Fourth Identifier)	"Tag No."	Instrument Tag Number (Third & Fourth Identifier)	"Tag No."
Network: Serial Communications	NS						
Ethernet Network	NE						
Modbus Network	NM						
Profibus Network	NP						
Fibre Network	NF						
Example 1: Power Cable to Flow Indicator Transmitter No. 001 from JB 02				EP/001JB02/FT001			
Example 2: Power Cable to Level Indicator Transmitter No. 001 from MCC01				EP/002/MCC01/LIT001			
Example 3: 4-20mA signal from Flow Indicator Transmitter No. 003 to MCC 05)				I/001/MCC05/FT003			
Example 4: Screw Press No1 Solenoid Wash valve (a) to MCC04)				I/002/MCC04/XV01a			
Example 5: Fibre Optic Cable from Camera Network Switch in MCC01 to Camera Network Switch in MCC02				FO/001/NSC01/NSC02			

IA4.14 Acceptance Of Instrumentation

When all the testing and flushing on an instrument loop has been completed the contractor shall notify the Engineer in writing and request inspection. Defects attributable to the contractor shall be punch listed and shall be rectified at the contractor expense. The Engineer shall accept equipment in a particular area on a loop by loop basis in writing, but the contractor shall retain responsibility for the loop until the complete area is handed over and accepted in writing by the Engineer

IA5 INDUSTRIAL AUTOMATION AND NETWORK SPECIFICATION

IA5.1 Quality Assurance

IA5.1.1 Codes and Standards

The process instrumentation supplied shall comply fully with the applicable SANS/IEC/IEEE specifications as set out in the table below and all equipment shall bear the mark of approval of the South African Bureau of Standards. The latest issue of the SANS/IEC/IEEE/ NRS codes will be applicable.

SANS 10142-1 : National Standards for the wiring of premises
SANS 1507 : Electric Cables (300/500V to 900/3300V)
SANS 1574 : Electric Cables Flexible cords and flexible cables
SANS 1411 : Material of insulated electric cables and flexible cords
SANS 1803-1 : Lugs and ferrules for insulated cables
SANS 60793 : Optical fibres
SANS 60794 : Optical fibre cables
ISO/IEC 14763-3 : Fibre optic testing
EN 50288 : Multi-element metallic cables used in analogue and digital communications and control
ISO/IEC SANS 11801:2002 : Information Technology – Generic cabling for customer premises
SANS 1091:2004 : National Colour Standard.
SANS 1274-2005 : Coatings applied by the powder-coating process.
SANS 1186 : Information and Safety Signs.
IEEE 802.3-2005 : Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and physical layer specifications
IEEE 802.1AX : Link Aggregation
IEEE 802.1d : MAC Bridges
IEEE 802.1Q : VLAN Tagging

IEEE 802.1w : Rapid Spanning Tree Protocol
IEEE 802.1X : Port Based Network Access Control

IA5.2 Programmable Logic Controllers (PCS)

IA5.2.1 PLC Hardware & Engineering

New Modicon M580 PLC's shall be supplied, installed, programmed, tested and commissioned for the complete control and operation of the respective existing and new plant installed. The PLC's and the required components shall be supplied as specified in the EWS standardised preferred equipment list.

The Contractor's engineering design shall include for all cubicles and hardware required for PLC control, and shall include comprehensive equipment lists, cubicle GA drawings and Control Centre drawings, I/O schedules and functional descriptions.

Provision shall be made for PLC control of all items require, plus allowance for expansion.

The Contractor shall furthermore ensure that the complete design, installation, commissioning shall include all necessary cabling, interfacing, connections, mountings etc. to ensure that the final product is complete, functional and to a good engineering standard.

The Contractor shall provide the following documentation to the integrator to enable the integrator to complete his scope. Documentation shall be at "For Construction" revision.

- Plant P&ID's
- IO Lists including:
 - instrument ranges;
 - alarm setpoints;
 - IO allocations per PLC system/rack/card;
- Plant network layout
- SCADA Hardware specifications

On completion of electrical and control panel manufacture, the contractor shall complete a Factory Acceptance Test (FAT) of all panels at his premises before delivery to site. The contractor shall inform the engineer that panels are ready for FAT and a team including the employer, the engineer, and the integrator shall attend and witness the FAT.

Acceptance of the FAT shall require acceptance by the employer, the engineer and the integrator.

The integrator has then accepted the panels for site tests and commissioning.

IA5.2.2 Software Engineering

The integrator shall utilise the latest revision Control Expert Software Program for the programming of the PLCs. The integrator shall provide their own computer for the programming and software engineering and on completion of the project the engineered software shall be transferred to the Employer. The software shall remain the property of the Employer with all copies kept by the Integrator during the course of the contract transferred to the Employer on completion of the Contract. No password protected codes will be accepted.

The integrator shall use information provided by the contractor and the EWS representative to develop the Function Design Specification (FDS) for approval by the EWS representative, prior to detailed software development.

Additional information shall be provided to the integrator in the form of the Process and Control Description which will assist with the FDS development.

The software engineering shall be developed in accordance with the final design P&ID and the FDS, which will include information from the Process and Control Description and sample FDS.

All control loops in the software engineering shall be based on an island control basis for the various process sections.

Software engineering shall be done using a structure format of function blocks to facilitate program simplicity and fault finding.

Certain standard programming function blocks might be provided by EWS to the successful tenderer to facilitate standardisation and shall be incorporated when programming the PLC and HMI for each section.

The integrator shall however be required to develop new function blocks in consultation with the Employer and the Engineer for approval prior to implementing the program.

The integrator shall allow for a minimum of three reiterations of the PLC program for changes as may be requested by the Employer and EWS representative without their pricing for this work.

IA5.2.3 I/O List

The Process and Control Description is to be read in conjunction with the P&ID drawings and single line schematic diagrams.

The Contractor, on completion of design, shall submit to the EWS representative comprehensive I/O lists for the new PLC in the form of a I/O list. This list shall be the expansion of the instrumentation index supplied at tender stage and shall include information listed in section 1.2 above.

The resultant I/O's shall be forwarded to, and used by the integrator for configuration of the respective process PLC's and to provide the necessary input to the overall HMI system to be installed under this Contract.

IA5.3 **Human Machine Interfaces (HMI)**

IA5.3.1 Hardware

For the local interaction and control of the respective plant areas the contractor shall supply and install Schneider Magelis 15" Graphic Terminal (HMI) (model number) units.

Each MCC shall be fitted with an HMI.

IA5.3.2 Software

Integrator Scope

The integrator shall use the latest revision Vijeo Designer Software Program for programming the HMIs. The integrator shall provide his own computer for the programming and on completion of the project transfer the software and licence to the Employer.

The software engineering shall be developed in accordance with the final design P&ID, the Process and Control Description and sample Process Control Philosophy. All control loops in the software engineering shall be based on an island control basis for the various process sections.

Software engineering shall be done using a structure format of function blocks to facilitate program simplicity and fault finding.

Certain standard programming function blocks and graphics might be provided by EWS to the successful tenderer to facilitate standardisation and shall be incorporated when programming the PLC and HMI for each section.

The integrator shall however be required to develop new function blocks in consultation with the Employer and the Engineer for approval prior to implementing the program. The new developed software shall however be required to follow the standard EWS display format.

The integrator shall allow for a minimum of three reiterations of the HMI program and display graphics and trending for changes as may be requested by the Employer and Engineer without their pricing for this work.

IA5.3.3 Control Network

The network design provides for a Modbus on Ethernet communication backbone which has been designed to support two systems namely:

- eThekweni Electrical MV Gear and Standby generator on site.
- eThekweni Water and Sanitation, PLC and SCADA data and control communications.

Network Hardware

The Contractor shall supply and install ethernet switches, which shall be high quality industrial grade.

Network switches utilised in the design shall be the standard preferred model managed switches as specified in the Schedule of Quantities.

The switches shall have the option to accept both fibre and copper cable in order to reduce the number of media convertors required. Configurable ports are preferred for flexibility.

The manufacturing details in respect of the panels to house the network switches is covered under the Motor Control Centres.

Network ConfigurationIntegrator Scope

The integrator shall configure each switch for maximum efficiency of the data transfer between his configured PLC's and SCADA systems.

Documentation

The integrator shall include design drawings & documentation to the SCADA system and allow for retrieval of documentation or drawings from the operator accessible system help screens.

Available documentation shall include:

- Process & Control Description
- Functional Design Specification

Available drawings shall include:

- Control Network Overview Layout
- Power Distribution Schematics & Drawings
- PLC Card Wiring Diagrams
- Loop Sheets
- MCC Schematics
- Instrument Data Sheets