

**Design, Build and Commissioning of 7 MLD
Common Effluent Treatment Plant (CETP) and
0.5 MLD Package Sewage Treatment Plant (STP)
at DPIA on EPC basis with 4 years Operation and
Maintenance -Package B**

VOLUME 3

PART 3 GENERAL ICA SPECIFICATIONS

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1. GENERAL

1.1 Scope

- 1.1.1 This specification covers the general requirements of ICA system for Sewage Treatment Plant (STP), Common Effluent Treatment Plant (CEPT) for Current Phase in DPIA Node Package -B
- 1.1.2 The Contractor shall be responsible for the Design, Engineering, Sizing, Selection, Procurement, Supply, Delivery to site, Installation, Testing, Pre-commissioning and commissioning of all equipment, fixtures and fittings necessary to complete the ICA installation whether detailed herein or not.
- 1.1.3 Supply and installation of all ICA items as detailed in the applicable P&ID.
- 1.1.4 Supply and installation of control system (SCADA, PLC, Panels) and associated equipment's required for safe and reliable control.
- 1.1.5 Supply and installation of instrumentation cables and associated supports. The cabling installation shall include supply, install, and gland, terminate, label, and test, all instrumentation and telemetry/signal cabling associated with the ICA system provided and installed under the Contract.
- 1.1.6 Supply and installation of all bulk items like Junction boxes, trays, glands, canopies, conduits etc.
- 1.1.7 Construction and installation in coordination with the Civil Contractor, of all required cable draw-pits, ducts and trenches.
- 1.1.8 Compliance with the requirements of this specification does not relieve the CONTRACTOR from the responsibilities of furnishing the Instrumentation and Control with proper design, meeting all the specified rated operating and service conditions.
- Eventually, All Interfacing of STP/CETP SCADA system with the MSI/ICCC to be envisaged by the EPC Contractor. Further all required hardware (including OFC cables from Plot boundary to the Control room for integration of SCADA with ICC), Software (including suitable API's) & civil works required to achieve this Interfacing is in the scope of the EPC Contractor.

1.2 Abbreviations

- 1.2.1
- API – American Petroleum Institute.
 - AVL – Approved Vendor List.
 - BSI - British Standards Institute.
 - CETP – Common Effluent Treatment Plant.
 - EWS- Engineering Work Station
 - FAT – Factory Acceptance Test.
 - HMI – Human Machine Interface.

- ICA – Instrumentation, Control and Automation.
- IEC - International Electrotechnical Commission.
- ISO - International Organization for Standardization.
- I/O- Input / Output
- LCP: Local Control Panel
- LAN: Local Area Network
- MCC – Motor Control Centre.
- NEMA – National Electrical Manufacturers Association.
- NFPA - National Fire Protection Association.
- OCU – Odour Control Unit.
- OWS- Operator Work Station
- P&ID - Process and Instrumentation Diagram.
- PLC – Programmable Logic Controller.
- PCS – Process Control System.
- RTD- Resistance Temperature Detector
- SAT – Site Acceptance Test.
- SCADA – Supervisory Control and Data Acquisition.
- STP – Sewage Treatment Plant.
- VDU- Visual Display Unit.

1.3 Codes and Standards

The installation, testing and commissioning shall be done in accordance with latest revision of applicable local and international codes, standards, regulations. Where conflicts exist between the local codes and standards, local codes shall govern.

A non-exhaustive list of applicable standards are as follows:

BS 1646	Symbolic Representation for Process Measurement Control Functions and Instrumentation - Basic Requirements.
BS 60529	Degrees of Protection Provided by Enclosures (IP Code).
BS 7671	Requirements for Electrical Installations. IEE Wiring Regulations.
BS EN 60228	Conductors in Insulated Cables.
BS EN 837	Pressure Gauges.
BS EN 6447	Specification for Absolute and Gauge Pressure Transmitters with Electrical Output.
BS 6739	Code of Practice for Instrumentation in Process Control Systems: Installation Design and Practice.

IEC 60447	Basic and Safety Principles for Man-machine Interface, Marking and Identification - Actuating Principles.
IEC 61131	Programmable Controllers.
BS EN 60204	Safety of Machinery
BS EN 50170	General Purpose Field Communication
ISBN 0 86341 233 5	IEE Guidelines for The Documentation of Computer Software for Real Time and Interactive Systems
BS EN 61000	Electro-Magnetic Compatibility
IEC 60654	Operating Conditions for Industrial Process Measurement and Control Equipment.
IEC 60625	Interface System for Programmable Measuring Instruments
IEC 60902	Industrial Process Measurement and Control – Terms and Definitions
IEC 60839	Alarm and Warning Systems
ISO 3511/1	Process Measurement Control Functions and Instrumentation Symbolic Representation

1.4 Environmental Details

The general site details common for STP & CETP are summarised in Table below.

Parameters	Values	Unit
Altitude of the site	Less than 1000	meters above MSL
Minimum Ambient temperature	3.5	Deg C
Maximum Ambient temperature	45	Deg C
Average Relative Humidity	100.6% max, 40% min	%
Natural Ground level (NGL)	Less than 1000	meters above MSL

1.5 Engineering Units

The instrument ranges and scale calibration shall be in metric units according to the international system of units (SI) as listed below:

Parameters	Unit
Flow liquid and vapor	M ³ /hr
Gas	Nm ³ /hr
Volume	M ³
Pressure	bar
Level	Mm, m Note-1
Temperature	Deg C
Conductivity	Micro Siemens / cm
Turbidity	NTU

pH	pH
BOD	mg/l
TSS	mg/l
Gas Concentration	PPM
Rotating Speed	RPM
Frequency	Hz
Current	A
Voltage	V

Note: HMI display of level instruments shall be shown in %.

1.6 Responsibility

- 1.6.1 Contractor shall be responsible for the selection and installation and commissioning of ICA system including but not limited to instruments indicated in the P&ID's. The P&ID's indicate the requirements and locations of instrumentation necessary to control and monitor the STP and CEPT operation. If any equipment which is not shown in the P&ID, but necessary for the safe and reliable operation, then it shall be the responsibility of Contractor to fulfil the requirement at no extra cost and no time delay to the Owner.

1.7 Accuracy

- 1.7.1 The intended use of a measured value will determine the accuracy requirement. Those instruments whose measured values are used directly by an automated control system will demand high accuracy ($\pm 0.5\%$). Instruments that measure values used by operators to monitor the process but do not directly control the process may be of lower accuracy ($\pm 1.0\%$). Where instruments are provided purely for display, these may be low accuracy ($\pm 5.0\%$). Accuracy for particular instrument types will be specified in the relevant sections below.
- 1.7.2 The method or location of installation can have a major effect on the accuracy of the measurement generated by any instrument. All instruments shall be installed in accordance with the instrument manufacturers' installation requirements.

1.8 Repeatability

- 1.8.1 Repeatability is defined as the ability of the system to reproduce output readings when the same measurement is made under the same conditions and in the same direction. It is thus a measure of consistency of measurement.
- 1.8.2 A highly accurate instrument shall give highly repeatable measurements, however an instrument which gives highly repeatable measurements may not give accurate measurements. All instruments, regardless of accuracy, shall be required to give repeatable measurements.
- 1.8.3 Repeatability for all instruments provided shall be $\pm 0.5\%$.

1.9 Ingress Protection and Instruments Materials

- 1.9.1 Outdoor instruments shall be weatherproof to a minimum standard of IP65 as per IS/IEC 60529 and for services (such as valve chamber, wet well, and flow meter chamber) where

there is a risk of flooding, the IP rating shall be IP68. Instrument materials shall be adequately corrosion resistant. In general, all wetted parts, process connections and dial display materials of instruments shall be stainless steel 316.

1.10 Lightning Protection

- 1.10.1 Any exposed cable connecting to an instrument which is located outdoor, shall be provided with a lightning protection barrier at the entry point of Instrumentation and Control panel (ICA Panel).

1.11 Mounting

- 1.11.1 Field mounted instruments shall be mounted on purpose made brackets, welded, bolted or clamped to the equipment structural steelwork or building fabric/steelwork. No cutting away of structural steelwork or building fabric/steelwork shall be carried out without the written consent of the Engineer.
- 1.11.2 Brackets shall be fabricated from stainless steel 316.
- 1.11.3 All fixing lugs shall be used. Where it is necessary to drill holes in any enclosure for fixing purposes, washers shall be fitted to maintain the original enclosure IP rating.
- 1.11.4 The bolts in brackets or supports that are subject to vibration shall have spring washers fitted. All fixing nuts, bolts and washers shall be of stainless steel 316.
- 1.11.5 All instruments shall be installed so that they are not subject to excessive vibration or to mechanical stress and are not exposed to extreme high temperatures or direct sun radiation.
- 1.11.6 Instruments shall be installed in such way they can be easily mounted, removed and can be easily read.
- 1.11.7 As a minimum, all equipment mounted in control rooms shall be suitable for operation at 45°C. Field mounted equipment shall be suitable for operation up to 50°C and shall be provided with sun shields.

1.12 Name Plates and Tagging

- 1.12.1 All field instruments, and cabinets/panel mounted instruments shall have 316 stainless steel tag plates/name plates permanently attached to them. Details of proposed inscriptions shall be submitted to the Engineer for approval before any labels are manufactured. The nameplates shall be fixed to the mounting plate, the mounting bracket or the junction boxes door/cover with stainless steel (type AISI 316), M4 bolts and nuts, self-tapping screws or pop-rivets.

1.13 Qualification Criteria for Instrumentation and Automation Vendor/integrator

- 1.13.1 Supplier's / Manufactures qualifications, indicating years in business, service capabilities and policies, warranty definitions, spare parts support, and a list of similar installations.

- 1.13.2 The Manufacturers / Suppliers shall be operating under an accredited ISO 9001 or above Quality System. All hardware shall be of the most current technology and Versions from the Manufacturer. All hardware and software shall be from the system manufacturer.
- 1.13.3 The SCADA /Automation sub-contractor shall be a reputed System manufacturer or System integrator with an experience of having executed ICA projects within India or outside India and shall demonstrate capability and resources for integrating/interfacing control systems from different manufacturers as well as coordination with multiple agencies for contract execution.
- 1.13.4 The system supplier must be an authorized system integrator for the named PLC hardware/SCADA & ODMS software supplier. Verification certificates shall be submitted directly from the manufacturer of the PLC hardware/SCADA & ODMS software supplier. In addition, submit references for minimum of (5) locations where the automation equipment has been successfully installed, including name, address and telephone number for the appropriate utility person to contact.
- 1.13.5 All hardware and software proposed shall have been successfully used in a similar water application for a period of at least five (5) years and be from established and reputable suppliers.
- 1.13.6 Upgrades and improvements to the manufacturers standard system that are released before the expiration of the warranty period shall be supplied, installed and commissioned at no additional cost.
- 1.13.7 All the instrumentation and control system items shall be from approved vendor list (AVL).

1.14 Utility and Earthing Requirement

1.14.1 Power Supply Requirement

Table 1: Power Supply for Project

S. No.	Description	230VAC, +/- 2%, 50 ± 1% Hz. UPS	110V DC (± 10%)	24V DC (Note-1)	415V AC, ± 5% VAC 50 ± 2% Hz (3 phase)	230 VAC, +/- 10%, 50 ± 1% Hz. Non-UPS
a)	SCADA / PLC	☒	☐	☒	☐	☐
b)	Package Control System	☒	☐	☒	☐	☐
c)	Solenoid Valves	☐	☐	☒	☐	☐
d)	2- wire Instruments	☐	☐	☒	☐	☐

e)	Input Interrogation Voltage	☐	☐	☒	☐	☐
f)	F&G Devices	☐	☐	☒	☐	☐
g)	Fire Alarm Panels	☒	☐	☐	☐	☐
h)	Building Cabinets Lighting	☐	☐	☐	☐	☒
i)	Local Panel Cabinets Lighting	☐	☐	☐	☐	☒
j)	4- wire Instruments	☒	☐	☐	☐	☐
Note: 24 VDC for all the field instruments will be derived from respective systems.						

1.14.2 Air Supply

Instrument air shall be the medium for pneumatic actuation.

All pneumatic instruments, actuators shall have enough margins such that they can even operate satisfactorily with 4 bar air supply pressure.

For packages instrument air shall be provided at 4 bar at the package skid battery limit. Further distribution shall be done by the package vendor.

1.14.3 Earthing

Internal grounding up to the earth busbar shall be done by the PLC / LCP Supplier. External grounding i.e. cabinet / LCP to main earthing system shall be done by the CONTRACTOR.

Earth stud which can accept up to 50 mm² earthing conductor shall be provided for the cabinet / LCP.

Junction boxes shall be connected to nearest electrical earth via 10 mm² earthing conductor.

1.15 Electrical and Instrumentation Interface

1.15.1 Signals for monitoring and control of motors / drives shall be hardwired to STP / CETP PLC/SCADA from the switchgear. Digital outputs to switchgear shall be provided with 24 VDC interposing relays located in the respective switchgear panels.

1.15.2 For all motors / drives following signals shall be hardwired to the PLC/SCADA:

- Motor Available Status (no fault in electrical system and H-O-A switch in auto position)
- Run Status
- Trip Status

- Speed signal from VFD and speed reference to VFD
- START/STOP maintained Command from PLC/SCADA, as applicable
- TRIP Command from PLC/SCADA, as applicable

1.15.3 Motor winding temperature signals shall generally be wired directly to MCC, if not specified otherwise on the P&ID(s) for packages.

1.15.4 Bearing RTD and vibration signals, if any, shall be wired to PLC/SCADA.

1.15.5 Where two or more motors are in duty/standby configuration, then a duty/standby switch is to be provided in the PLC/SCADA.

1.16 Inspection and Testing

1.16.1 Inspection and testing of instrumentation and control shall be performed by a third party inspection agency appointed by contractor.

1.16.2 Owner / Engineer will witness the factory acceptance testing for the Control System, Package PLC system, LCP. Owner / Engineer also reserves the rights to witness the testing for instrumentation.

1.16.3 Vendor shall provide a complete inspection and testing plan and the test procedures (FAT, SAT, etc) for review by Owner / Engineer.

1.16.4 Contractor shall provide method statements, procedures for all the instrumentation and control site works.

1.16.5 Factory Acceptance Test (FAT) and Site Acceptance Test (SAT)

Contractor shall submit a written plan of testing at least 15 days prior to the test demonstration for control system. The plan shall be submitted for approval by Engineer/Owner. It shall include procedures to be applied in testing of hardware and software systems including a description for each system, test methods, testing instruments and a list of the equipment involved together with the functional parameters to be recorded on each item.

Tests based on the approved procedure shall be witnessed by the Engineer and Owner at the Manufacturer / Supplier's facility for the FAT).

The Contractor shall provide the following:

- a) Test procedure (For FAT and SAT)
- b) ICA shop drawings
- c) Calibration certificate
- d) Test documentation, schedules and logs.
- e) Manufacturer's internal factory acceptance test results and records prior to witnessing of FAT/SAT.

Factory test carried out for primary elements and instruments shall include pressure and calibration tests. Certificates shall be provided for pressure test, calibration test and conformity to specifications.

1.17 Quality Control

- 1.17.1 The contractor/vendor shall demonstrate that he operates a quality system in accordance with an internationally recognized standard such as ISO 9001:2000. The effectiveness of the quality system and the Vendor's compliance with it shall be subject to monitoring by Owner / Engineer and in addition, may be audited by an agreed period of notice.
- 1.17.2 The contractor/vendor shall submit a quality control program for Owner / Engineer review at the time of proposal. The contractor/vendor shall provide facilities for and cooperate with Owner / Engineer and its designated authorized inspectors during manufacturing, assembly and testing.
- 1.17.3 All signed records shall be provided for calibration, installation, functional testing, loop checking, SAT, pre-commissioning checks.

1.18 Installation and Commissioning

- 1.18.1 The Contractor shall install and commission the supplied instruments. The Contractor shall provide the following:
- a) Commissioning Plan
 - b) Commissioning Manual
 - c) Commissioning Log
 - d) Test Documentation, schedules, logs and final status report

1.19 Training

- 1.19.1 Training shall be provided for the operators, maintenance personnel, engineers for control system, package PLC, analysers and complex instruments.
- 1.19.2 Training shall be as per the terms and conditions in the purchase order and shall cover the following areas as a minimum:
- Operation
 - Maintenance / troubleshooting
 - Configuration

1.20 Painting

- 1.20.1 Contractor / Vendor shall provide the painting specification for Engineer/Owner's review and approval.

1.21 Guarantee and Warranty

- 1.21.1 The contractor/vendor shall guarantee the mechanical design, material of construction, workmanship and performance of the instrumentation and control for the specified

application and operation for the package equipment. This guarantee shall be for a period of Twelve (12) months from the date of commissioning or Eighteen (18) months from the date of supply whichever is earlier.

1.22 Drawing and Documents

1.22.1 As a minimum, the Contractor shall submit the following for Engineer/Owner's review and approval:

- a) All pertinent information regarding the reliability and operation of the equipment to be supplied.
- b) Manufacturer's original format catalogue data and descriptive information for all major components of the system.
- c) The Owner or the Engineer, at their sole choice and discretion, may request a demonstration of the proposed equipment.
- d) Equipment other than specified may be considered for approval. It shall be the Contractor's obligation to submit data and information to allow the Owner and Engineer to consider the equality of the substituted items to that specified. It is the Contractor's responsibility to meet the entire intent of the specifications. Deviations from the specified items shall be at the risk of the Contractor until the date of final acceptance by the Owner and the Engineer. Accepted submittals on substitute equipment shall only allow the Contractor to proceed with proposing a substituted item and shall not be considered equal until such time as the Owner and the Engineer have completely accepted the substituted item.

1.22.2 The Contractor shall submit comprehensive documentation (issued for approval) including but not limited to:

- a) Instrument data sheets
- b) Calculations
- c) Functional specification for SCADA / PLC system
- d) Instrument Index including packages
- e) I/O List with alarm and instrument settings
- f) Instrument cable schedule
- g) Instrument junction box schedule
- h) Interconnection wiring diagrams
- i) Cable block diagrams
- j) Instrument hook-up drawing
- k) Instrument Installation drawings
- l) Cable / tray routing drawings
- m) Control System architecture
- n) Control room layout

- o) Instrument location plan
- p) General arrangement drawings of instrument and control panels, fully dimensioned in plan and elevation views, showing foundation and fixing details, access doors, clearances, cable-entry positions, weight and lifting arrangement.
- q) Other vendor drawings for Instruments / valves and control system
- r) Inspection test plan
- s) Certificates (calibration, material, electrical etc.)
- t) Instruments loop-diagram
- u) Spare part list
- v) O & M manual

1.23 Spares and Special Tools

- 1.23.1 Spares shall be provided as recommended by equipment manufacturers and as per the requirements of the Contract.
- 1.23.2 Installed Spares shall be defined as follows:
 - a) Each Junction Box shall be designed to accommodate all 25% spare cables (wired Terminations)
 - b) Cable Tray / trench shall have 20 % spare space for future cables.
 - c) Instrument Air Sub-header size shall be as Up to 5 users (4 users + 1 spare)
 - d) Multi Cable Transit (MCT) / Conduit shall have 50 % spare space for future cables.
 - e) Installed Engineering Spares to the tune of 20 percent for each sub-system and for each type of module. The basis is explained below:
 - i. 20 percent spare input/output of each type shall be considered for calculating the I/O modules and related accessories.
 - ii. For all serial input/outputs, 20 percent serial I/O ports of each type shall be provided.
 - iii. 20 percent spares for relays, switches, lamps, fuses, circuit breakers, barriers, isolators, terminals etc.
 - iv. Spare pairs of the incoming cables shall be terminated on spare terminals in the marshalling and other cabinets
 - v. Engineering shall take into account 20 percent installed engineering spares including processor loading
- 1.23.3 Special tools required (if any) shall be part of vendor scope of supply. Special tools shall cover maintenance and configuration tools for instrumentation and control.

2. INSTRUMENTS, ACTUATORS AND CABLES

2.1 General

- 2.1.1 All Control and Instrumentation systems shall be designed for a minimum life of 20 years. Spare parts and support shall be available for this period.
- 2.1.2 Engineering units shall be as per the clause no.1.5 of this document.
- 2.1.3 Makes (manufacturer) for the instruments shall be as per the Approved vendor list (AVL).
- 2.1.4 All field transmitters shall be smart transmitter with 4-20mA, 2-wire HART output. All transmitters shall be provided with integral digital indicators configured in engineering units. Sunshade shall be provided for all transmitters located in open area.
- 2.1.5 Additionally, a removable enclosure with transparent window shall be provided for instruments where water splashing occurs like membrane tank, biological tank, cooling tower etc.
- 2.1.6 Material of construction shall be as per the piping material specification and instrument data sheets. Contractor/vendor may propose other material, subject to Owner / Engineer approval, if it is superior than specified.
- 2.1.7 Flying leads are not acceptable; hence all field instruments shall be provided screw type terminals.
- 2.1.8 All electrical entries shall be NPT type. Unused entries shall be provided with suitable blanking plugs.
- 2.1.9 Switches (pressure, level, flow, temperature, etc.) shall not be used and its use requires Owner / Engineer approval except for pump seal instrumentation, fan vibrations.

2.2 Level Instruments

Ultrasonic Level Transmitter

- 2.2.1 Ultrasonic level detectors shall be used for most situations where a continuous level measurement is required. The ultrasonic level detector system shall comprise a transducer, a separate transmitter unit and an interconnecting cable, operating on the time-of-flight principle.
- 2.2.2 The transducer shall be a non-contact type suitable for continuous measurement of level. The transducer shall be weather resistant and safe against submersion (IP 68), and shall incorporate an integral temperature sensor to allow for temperature compensation of the measured level. The transducer shall not be affected by the measured liquid and shall be insensitive to dirt build-up. The transmitter shall support fixed target suppression (removal of false echoes) and first echo recognition (for correct indication in spite of double echoes).
- 2.2.3 The transmitter shall be microprocessor based with an integral operator interface housed within a corrosion resistant enclosure. The operator interface shall have a

numeric display, bar graph display, and a simple push button interface. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.

2.2.4 The transmitter will be powered from a 24 VDC supply. Output shall be by 4-20 mA DC with HART superimposed and shall be proportional to the measured value. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.

2.2.5 The transducer shall have a blocking distance no more than 10% of the measurement range and a 3dB beam angle no wider than 10°. The system shall give a measurement of $\pm 0.5\%$ of the measurement span.

Ultrasonic Level Transmitter with two sensors and two analogue (4-20mA) HART superimposed outputs.

2.2.6 Ultrasonic level transmitter with two separate sensors shall be used where a continuous differential level measurement is required. The ultrasonic level detector system shall comprise a separate two transducers, one transmitter unit with two analogue outputs and two numbers interconnecting cable.

2.2.7 The transducer shall be a non-contact type suitable for continuous measurement of level. The transducer shall be weather resistant and safe against submersion (IP 68), and shall incorporate an integral temperature sensor to allow for temperature compensation of the measured level. The transducer shall not be affected by the measured liquid and shall be insensitive to dirt build-up. The transmitter shall support fixed target suppression (removal of false echoes) and first echo recognition (for correct indication in spite of double echoes).

2.2.8 The transmitter shall be microprocessor based with an integral operator interface housed within a corrosion resistant enclosure. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. The transmitter shall have simple push button to alternate between readings of two sensors. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.

2.2.9 The transmitter will be powered from a 24 VDC supply. Output shall be by 4-20 mA DC, HART superimposed and shall be proportional to the differential level. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.

Hydrostatic Pressure Type Level Transmitter

2.2.10 The transmitter shall comprise a hydrostatic pressure sensor suitable either for mounting on a flanged connection or for insertion through a borehole by means of a connecting cable. This specification is based on the latter application, which requires the

most stringent features. The flanged type shall generally follow the same specification except for the enclosure class that may be relaxed to IP65.

- 2.2.11 The hydrostatic pressure sensor shall comprise a measuring cell mounted in a stainless steel probe tube fitted with a stainless steel diaphragm. The diaphragm shall be protected by a fine mesh metal grid and a protective cover. The probe tube shall be filled with silicon oil which shall transmit the hydrostatic pressure of the liquid column to deflect a silicon diaphragm with a thin film strain gauge. Contractor shall provide a certificate for non-toxicity for the filling fluid. Variations in pressure on the surface of the liquid shall be compensated by an air tube passing through the connecting cable to the other side of the silicon diaphragm. The transducer should have over pressure rating of at least 4 times nominal pressure. A durable conical cable sealing shall be fitted on the probe tube with a moisture barrier on the pressure compensation line for long term stability. In case of failure the sensing module shall be replaceable.
- 2.2.12 Used materials shall be AISI 316 Stainless Steel for Sensor Tube and Diaphragm, Viton for Gasket and Polyethylene insulated and bound with steel webbing for cable.
- 2.2.13 The probe and cable shall be mounted by stainless steel 316 pressed clamps cable holder including connection box or a housing with a 38mm (nominal) threaded connection. The diameter of the sensor shall be less than 30 mm to facilitate easy insertion and withdrawal from the guide tube.
- 2.2.14 The cable probe shall be certified for IP68 and housing/connection box to a minimum of IP65 above ground level. Minimum over pressure resistance shall be 10 times.
- 2.2.15 The transmitter shall be microprocessor based with a remote operator interface housed within a corrosion resistant enclosure. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.
- 2.2.16 The transmitter shall be powered from 24 VDC supply. Output shall be by 4-20 mA current loop and shall be proportional to the differential level value. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.

Sludge Blanket Level Transmitter

- 2.2.17 Sludge blanket monitors shall be used to detect the depth of sludge within a Waste sludge holding tank, allowing operators to take remedial action before sludge levels become problematic. The sludge blanket monitoring system shall comprise a transducer, a separate transmitter unit and an interconnecting cable. Where the transmitter is located on a travelling bridge assembly, option for wireless connection to a fixed remote unit will also be provided.
- 2.2.18 The transducer assembly shall comprise the sensor and any mounting hardware required to allow the sensor to operate correctly.

- 2.2.19 The sensor shall be fixed on a Waste sludge holding tank (travelling or fixed bridge assembly). Ultrasonic pulses will be emitted by the sensor and reflected by the sludge blanket to the sensor. The sensor shall incorporate a temperature sensor to compensate for differences in speed of sound transmission. An air purge cleaning system shall be provided.
- 2.2.20 An optical suspended solid concentration sensor, suspended from a cable which may be raised or lowered using a stepping motor and cable drum assembly. The suspended solids concentration sensor should use a double beam pulsed light technique. The system should automatically raise or lower the sensor until the measured solids concentration matches a user define set point. The calculated depth will then define the sludge blanket level.
- 2.2.21 The transmitter shall be microprocessor based with an integral operator interface housed within a corrosion resistant enclosure. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password. In addition, the different sensing mechanisms described above shall require certain specific transmitter features, as described below:
- 2.2.22 Transmitters for use with submerged ultrasonic sensors shall incorporate an air compressor to provide compressed air to serve the sensor air purge cleaning system.
- 2.2.23 Transmitters for use with optical suspended solid concentration sensors shall incorporate the control of the sensor raising/lowering mechanism.
- 2.2.24 In each case, the transmitter shall be bridge mounted. Where the bridge is a travelling assembly, measurements shall be transmitted to a remote fixed location. Rotating bridge slip rings shall not be used for the transmission of signals.
- 2.2.25 In either case, the transmitter will be powered from a 230 VAC or 24 VDC supply (which may be provided via rotating bridge slip rings). Output shall be by 4-20 mA current loop and shall be proportional to the measured value. A digital output shall also be provided which shall be configured to generate an alarm in the event that the level detection system fails.
- 2.2.26 The system shall give a measurement of $\pm 1.0\%$ of the measurement span.

Level Gauges

- 2.2.27 Local level gauges for the surge vessels and reservoirs shall be of the direct reading magnetic type where a permanent magnet mounted in a float drives a series of flaps. A small permanent magnet shall be attached to each flap to ensure that the flaps remain in a given position even when severe vibration occurs. The float shall be concentric magnetic design with unsupported sections to provide a strong and uniform magnetic field. The external mounted float guiding tube / chamber shall be of 304 SS and the float shall be AISI 316 SS. The housing of the flaps shall be dust and watertight. A graduated

scale made of stainless steel with 1 cm division shall be fixed adjacent to the float guiding tube/chamber.

- 2.2.28 Only one (1) level gauge shall preferably be used on a vessel. If, however, two (2) or more level gauges are required, they shall be installed in such a way that the visible lengths overlap by at least 50 mm.

Conductivity Probes

- 2.2.29 Conductivity probes shall be used to give point level measurements. These may be used for control of simple applications, as backup control devices for a continuous level instrument or to generate alarms.
- 2.2.30 A minimum of two electrodes are required, a metallic earth electrode which extends to the lowest point in the vessel, and a level electrode. The metallic level electrode is set at the desired switching point. When the liquid covers the tip of the electrode, an electrical circuit is completed between the level electrode and earth electrode.
- 2.2.31 The electrodes and their fixings shall be manufactured of non-corrodible metal, suitable for intermittent submersion.
- 2.2.32 The control/switching unit shall be suitable for mounting within a control panel on DIN rail. Output shall be volts' free contact or open collector. Sensitivity shall be easily adjustable to allow fine-tuning of the switching threshold.
- 2.2.33 The switching element shall be hermetically sealed snap acting micro switch rated for 2 amps at 24 V DC with gold plated contacts. Each switch shall be provided with SINGLE POLE DOUBLE THROW RELAY (SPDT) contact arrangements. The switch enclosure shall be weather proof to IP 65 of IEC 60529. Cable entry shall be ½" NPT.

Float Switches

- 2.2.34 Float switches shall be used to give point level measurements. These may be used for control of simple applications, as backup control devices for a continuous level instrument or to generate alarms.
- 2.2.35 The float switch shall comprise a tilt switch housed within a sealed plastic bulb. When no liquid is present, the bulb shall hang upright, supported by the instrument cable. The bulb shall be buoyant and float on the surface of the liquid, so that when the liquid level rises, the bulb floats on the surface. As the bulb makes the transition from hanging to floating on the liquid surface, the tilt switch inside shall operate.
- 2.2.36 The cabling shall provide cores for normally open and normally closed switching contacts, allowing the float switch to be used to detect a rising level or a falling level.
- 2.2.37 The switching element shall be hermetically sealed snap acting micro switch rated for 2 amps at 24 V DC with gold plated contacts. Each switch shall be provided with SINGLE POLE DOUBLE THROW RELAY (SPDT) contact arrangements. The switch enclosure shall be weather proof to IP 65 of IEC 60529. Cable entry shall be ½" NPT.

2.3 Flow Instruments

The provision of flow meters shall require the instrument to be fitted in accordance with the manufacturer's recommendations. It must include, if required, reduction tapers necessary to obtain suitable flow velocities past the detector heads. Indicate if the pipe is full filled pipe or partially filled pipe where this will affect the reading.

Electromagnetic Flow Transmitter

- 2.3.1 The flow meter shall comprise of a flow sensor and a transmitter unit. The transmitter shall be integral to the flow tube for above ground installations and separate from the flow tube for below ground installations such as chambers. The flow meter shall be of the electromagnetic type utilizing pulsed DC excitation and shall be microprocessor based. Each unit shall be of stand-alone type.
- 2.3.2 Electromagnetic flow meters shall operate on electromagnetic induction principles and shall consist of a detector head and signal converter system which shall comply with BS EN ISO 6817 and Traceability Group A1 of BS ISO 11631. The flow metering system shall provide pulse and analogue current outputs proportional to volume and rate of flow respectively.
- 2.3.3 The flow meter shall feature on-site field validation for sensor, transmitter and interconnecting cable. The flow meter shall be calibrated at the factory to its actual flow range in m³/hr. A factory calibration certificate shall be provided with the meters.
- 2.3.4 The flow sensor shall be manufactured from AISI 304 stainless steel metering tube with a non-conductive hard rubber liner to withstand process temperatures as per the data sheet. The liner material shall be abrasive resistant and approved for potable water use by WRC-UK or equivalent internationally recognized authority.
- 2.3.5 There shall be 2 nos. of measuring electrodes with built in reference electrode and empty pipe detection electrode as a standard item. The reference electrode shall ensure potential equalization between the sensor and the fluid and proper grounding of the installation. Electrode material shall be SS 316L or Hastelloy.
- 2.3.6 Detector heads shall be flanged to BS EN 1092. The flanges shall be compatible with those specified for the associated pipe work. Detector heads shall be fitted with an anti-roll system to prevent damage during storage. The flow meter shall have an empty pipe detection facility. The input impedance shall be 1015 ohms or greater so that electrode fouling does not affect signal and electrode seal integrity. The sensor data shall be stored in a built-in EPROM module.
- 2.3.7 Automatic cleaning of electrodes shall be possible through the transmitters.
- 2.3.8 Power and signal cables to the detector head shall be factory sealed only, potting 'on Site shall not be acceptable.
- 2.3.9 The electrical connections for cable entry for sensors with remote transmitters shall be ½" NPT with appropriate cable glands.

- 2.3.10 A minimum of ten (10) metres of interconnecting cable between sensor and the remote transmitter unit shall be included in the scope of supply. The interconnecting special cable shall be supplied from the manufacturer of the flow meter.
- 2.3.11 The transmitter unit shall be either integral with the flow sensor or remotely mounted to suit the application requirements.
- 2.3.12 The transmitter unit shall be microprocessor based, of modular design and shall be easily configurable through integral keypads. The electronics shall be of modular construction for ease of maintenance and future expandability.
- 2.3.13 The transmitter shall be provided with at least three (3) lines illuminated display for rate of flow and totalized flow indication. The data storage shall be on EEPROM to preserve data on power failure without battery backup. The unit shall have high electromagnetic compatibility according to IEC 801 recommendations.
- 2.3.14 The transmitter shall be housed in a robust die-cast aluminium enclosure with IP65 protection for both compact and remote versions and shall be IP68 for submerged application.
- 2.3.15 The unit shall be provided with extensive self-diagnostics for operational security with resulting error messages enunciated at the alarm output.
- 2.3.16 The transmitter will be powered from a 230 VAC or 24 VDC supply. All inputs and outputs shall be galvanically isolated from the power supply, the measuring circuit and each other.
- 2.3.17 The following outputs shall be available and configurable by the user:
- vi. Analogue, 4-20 mA. Analogue signal proportional to flow rate.
 - vii. Active / Passive (open collector) selectable to Pulse/Frequency output.
 - viii. Status configurable for limit values, end value switching, empty pipe detection, flow direction over ranging or instrument fault.
- 2.3.18 The transmitter unit shall be provided with two (2) no's. of suitable cable glands for power supply and signal cables.
- 2.3.19 Accuracy shall be better than + 0.25% of reading (actual flow rate) at flow velocity > 1 m/s with repeatability within + 0.1% of flow rate. The measurement shall be insensitive to entrained solid particles.
- 2.3.20 The transmitter unit shall be suitable for operation in an ambient temperature range of 0 to 50°C.

Ultrasonic Transit Time Flow Transmitter

- 2.3.21 Swimming of waves against the flow requires more power and more time than swimming with the flow. Ultrasonic flow measurement is based on this elementary transit time difference effect.
- 2.3.22 Two sensors mounted on the pipe simultaneously send and receive ultrasonic pulses. At zero flow, both sensors receive the transmitted ultrasonic wave at the same time, i.e. without transit time delay.
- 2.3.23 When the fluid is in motion, however, the waves of ultrasonic sound do not reach the two sensors at the same time. This measured "transit time difference" is directly proportional to the flow velocity and therefore to flow volume.
- 2.3.24 The flow meter shall comprise of two flow sensors and a transmitter unit. The flow sensor and the transmitter shall be supplied as an integral unit or the transmitter unit shall be remotely mounted from the flow sensor. The transmitter will be powered from a 24 VDC supply.
- 2.3.25 Output shall be by 4-20 mA, HART superimposed, current loop and shall be proportional to the flow value. A digital output shall also be provided which shall be configured to generate an alarm in the event that the flow detection system fails.

Open Channel Ultrasonic Flow Transmitter

- 2.3.26 Method to measure the volumetric flow in an open channel will be achieved by installing a flume or weir in a channel with a free discharge and measuring the liquid level upstream of the flume or weir. The level measurement shall be taken by an ultrasonic system using the time of flight principle.
- 2.3.27 The transducer shall be a non-contact type suitable for continuous measurement of level. The transducer shall be weather resistant and safe against submersion (IP 68), and shall incorporate an integral temperature sensor to allow for temperature compensation of the measured level. The transducer shall not be affected by the measured liquid and shall be insensitive to dirt build-up.
- 2.3.28 The transmitter shall be microprocessor based with an integral operator interface housed within a corrosion resistant enclosure. The transmitter shall be pre-configured with common flow/height characteristic curves for measuring flow rates with flumes and weirs. Other flow/height curves may be entered, measured values being obtained by interpolation between entered data. The operator interface shall have a numeric display, bar graph display, and a simple push button interface. All error codes, process variables, configuration data and other internal values shall be accessible and displayable on the integral operator interface. It shall be possible to limit access to configuration data parameters by means of a configuration password.
- 2.3.29 Input power required will be from a 24 VDC supply. Two analogue outputs shall be provided, corresponding to measured level and calculated flow, and a pulse output shall be provided along with a digital output to indicate fault status and total flow. The analogue outputs shall be by 4-20 mA current loop with HART superimposed and shall be proportional to the measured values. The pulse output shall be an open collector

output. Fault status shall be indicated by an open collector output, indicating system or process error, flow direction or low flow (if enabled).

- 2.3.30 The transducer shall have a blocking distance no more than 10% of the measurement range and a 3dB beam angle no wider than 10°. The system shall measurement level to an accuracy of $\pm 0.5\%$ of the measurement span. The flow measurement shall be accurate to $\pm 1.0\%$.

2.4 Pressure Instruments

Pressure Gauges

- 2.4.1 Pressure gauges shall be used for absolute pressure measurement. They shall be Bourdon tube, direct measure type with dial size 150mm. Wetted parts and case material shall be SS316. Shatter proof window and blow-out safety back plate shall be provided. . Pressure gauge case shall be liquid filling with bottom process connection and SS flexible pointer stop on dial. IP protection grade shall be minimum IP65 and accuracy $\pm 1\%$ of full scale for installation inside the chamber. Over load protection shall be 130%. Separate calibration certificate for each instrument shall be provided.

Pressure Transmitter

- 2.4.2 Pressure transmitters shall be of the direct sensing type with the sensing element as per manufacturer's standard. The diaphragm shall be hermetically welded to the measuring element assembly.
- 2.4.3 The transmitter shall be of a smart type. The measuring element shall be able to withstand a temporary/permanent overpressure to at least 30% of the specified range limits without calibration shift.
- 2.4.4 All wetted parts and the diaphragm shall be compatible with the process fluid and shall be of minimum AISI 316 SS/ceramic. The measuring assembly fill fluid shall be silicon oil, unless otherwise specified.
- 2.4.5 PTFE gaskets shall be applied as a standard, unless otherwise specified. The bolts and nuts shall be high tensile stainless steel.
- 2.4.6 The transmitter cover material shall be low copper aluminum. Enclosure class shall be according to IP 65 of IEC 60529, as a minimum.
- 2.4.7 The process connection shall be 1/2" NPT (M) and the electrical signal cable entry connection shall be 1/2" NPT unless otherwise specified in the data sheet. Unused electrical connections shall be plugged off with a recessed head screw in compliance with the specified electrical safety requirements. The screw material shall be of stainless steel for stainless steel enclosures. The signal cable termination points shall of the screw type.
- 2.4.8 The transmitter output signal shall be 4-20 mA with HART superimposed.
- 2.4.9 The transmitter power supply voltage shall be 24 VDC, for two-wire transmission system with a minimum power supply voltage of 12.5 VDC.

- 2.4.10 The transmitter electronics shall be microprocessor based.
- 2.4.11 The electronics system shall be provided with a reverse polarity protection circuit.
- 2.4.12 Zero and span shall be non-interacting, easily and continuously accessible. The external adjustment(s) should be provided with an environmental protection cover. Pressure gauges and transmitters shall have primary isolating valves, 2 or 3-way valve manifold and vents, in such a way that it has the facility to calibrate the gauges or transmitters without removal.
- 2.4.13 The transmitter shall be provided with integral digital indicator with scale identical to the calibrated range as indicated in the instrument data sheet.
- 2.4.14 The performance of the transmitter shall be as follows:
- 2.4.15 The transmitter accuracy including combined effect of linearity, hysteresis and repeatability shall be equal to or better than $\pm 0.25\%$ of calibrated span.

2.5 Temperature Instruments

Temperature Transmitter

- 2.5.1 The temperature transmitter shall comprise of a RTD sensing element in a thermowell with a head mounted transmitter unit.
- 2.5.2 Resistance thermometer shall consist of an outer metal sheath, containing a sensing element of annealed platinum resistance wire. The resistance and connecting wires shall be electrically insulated from the outer sheath by compacted magnesium oxide or suitable alternative compatible with the RTD operating temperature. The sheath end closure by seal welding shall be impervious to gases and liquids. Cracks, holes or defects penetrating the wall shall not be permitted. The tip shape is optional, rounded, flat or conical; the other end shall be hermetically sealed, suitable for an operating temperature as per the data sheet, to prevent the ingress of moisture. The sealed end of the element shall be provided with flange in accordance with DIN 43734, for terminal block and/or transmitter mounting and spring loaded screws for adjustment.
- 2.5.3 RTD elements shall be offered in 3-wire duplex configuration. The sheath shall have a nominal outside diameter of 6 mm + 0.1 mm.
- 2.5.4 The platinum resistance thermometer performance shall be in accordance with the requirements of IEC 60751, Pt 100 elements, having a resistance of 100 ohms at 0°C, with a fundamental interval of 38.5 Ohms to 100°C.
- 2.5.5 The resistance tolerance shall comply with Class A according to IEC 60751, where Class A tolerance (deg C) is $0.15 + 0.002 [t]$.
 $[t]$ = modulus of temperature in degrees Celsius without regard to sign.
- 2.5.6 The RTD elements shall be supplied with thermos-wells of 316 SS. The Thermowell shall be drilled from bar stock. Insertion length shall be to suit the application requirements.

The transmitter shall be of a smart type with modular design and compatible with 3-wire RTD sensor. The transmitter shall be attached directly to the sensor assembly.

- 2.5.7 The transmitter cover material shall be of low copper aluminium. Enclosure class shall be according to IP 65 of IEC 60529, as a minimum.
- 2.5.8 The electrical signal cable entry connection shall be 1/2" NPT, unused electrical connections shall be plugged off with a recessed head screw in compliance with the specified electrical safety requirements. The screw material shall be of stainless steel for stainless steel enclosures. The signal cable termination points shall of the screw type.
- 2.5.9 The transmitter output signal shall be 4-20 mA with HART protocol. It shall be possible to upgrade the transmitter output to foundation field bus standard in the near future.
- 2.5.10 The transmitter power supply voltage shall be 24 VDC, for two-wire transmission system with a minimum power supply voltage of 12.5 VDC.
- 2.5.11 The transmitter electronics shall be microprocessor based.
- 2.5.12 The electronics system shall be provided with a reverse polarity protection circuit.
- 2.5.13 Zero and span shall be non-interacting, easily and continuously accessible. The external adjustment(s) should be provided with an environmental protection cover.
- 2.5.14 The transmitter shall be provided with integral digital indicator with scale identical to the calibrated range as indicated in the instrument data sheet.
- 2.5.15 The performance of the transmitter shall be as follows:
- 2.5.16 The transmitter accuracy including combined effect of linearity, hysteresis and repeatability shall be equal to or better than ± 0.1 deg C.
- 2.5.17 The transmitter shall be provided with EMI/RFI integral transient protection also when the cover has been removed. The protection level shall be as per NAMUR recommendations and EMC directive compliance.

2.6 Analytical Analysers

Dissolved Oxygen Analyser

- 2.6.1 Dissolved oxygen monitoring systems shall comprise a transducer, transmitter and interconnecting cable.
- 2.6.2 The transducer assembly shall comprise the sensor and mounting hardware. Mounting hardware shall be provided for either rigid wall mounting, freely swinging suspended wall mounting or a floating installation with the float suitably anchored to a fixed location, as required by the application. The sensor shall be membrane covered amperometric type suitable for constant immersion, giving high O₂ selectivity and minimal maintenance requirements. The sensor shall also incorporate an integral temperature sensor. Cabling between the sensor and transmitter shall be easily

disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.

- 2.6.3 Also the sensor can be an optical sensor working on the fluorescence quenching principle suitable for constant immersion giving minimum maintenance and maximum availability. The sensor shall compensate for fluid temperature and air pressure. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- 2.6.4 The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate oxygen content and provide the option of displaying temperature if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.
- 2.6.5 Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.
- 2.6.6 The instrument shall give measurements at an accuracy of $\pm 0.5\%$ of the measured value and have quick response time. Drift shall be no greater than 1% of full scale per month, such that sensor recalibration shall not be a frequent requirement.

- 2.6.7 Ingress protection shall be IP65 as minimum.

PH/ORP Analyser

- 2.6.8 PH/ORP monitoring systems shall comprise a transducer, transmitter and interconnecting cable.
- 2.6.9 The transducer assembly shall comprise the sensor and any mounting hardware required. The sensor shall use a glass membrane electrode, the outer layer of which shall give high H⁺ ion selectivity, to supply an electrochemical potential dependent upon the PH/ORP value of the process fluid. The sensor shall be suitable for constant immersion, with minimal maintenance requirements. The sensor shall also incorporate an integral temperature sensor. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- 2.6.10 The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate PH/ORP and provide the option of displaying temperature if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.
- 2.6.11 Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured

value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.

- 2.6.12 The instrument shall give measurements at an accuracy of $\pm 0.5\%$ of the measured value and have quick response time. Drift shall be no greater than 1% of full scale per month, such that sensor recalibration shall not be a frequent requirement.

- 2.6.13 Ingress protection shall be IP65 as minimum.

Conductivity Analyser

- 2.6.14 Conductivity monitoring systems shall comprise a transducer, transmitter and interconnecting cable.

- 2.6.15 The transducer assembly shall comprise the sensor and any mounting hardware required. The sensor shall comprise two coaxial graphite electrodes arranged similarly to a capacitor. The electrical resistance (and hence its' reciprocal, conductivity) is measured according to Ohm's law. Specific conductivity is determined using a cell constant that is particular to the sensor geometry. The sensor shall be suitable for constant immersion, with minimal maintenance requirements. The sensor shall also incorporate an integral temperature sensor. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.

- 2.6.16 The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate conductivity and provide the option of displaying temperature if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.

- 2.6.17 Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.

- 2.6.18 The instrument shall give measurements at an accuracy of $\pm 0.5\%$ of the measured value.

- 2.6.19 Ingress protection shall be IP65 as minimum.

Turbidity / TSS Analyser

- 2.6.20 Measurement of turbidity/suspended solids concentration is important to allow the solids content to be assessed at various points in the treatment process. Turbidity/suspended solids monitoring systems shall comprise a transducer, transmitter and interconnecting cable.

- 2.6.21 The transducer assembly shall comprise the sensor and any mounting hardware required. The sensor shall function by the 90° scattered light principle. Light in the near-infrared range shall be emitted by an LED at a defined angle. Particles in the process liquid will scatter incident light and a photodiode shall measure light reflected back

towards the sensor. The LED and photodiode shall be sealed within the sensor behind scratch resistant windows. The sensor shall be suitable for constant immersion, shall incorporate a wiper to ensure that the LED light source and photodiodes remain clean at all times with minimal maintenance requirements. The sensor shall also incorporate an integral temperature sensor. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.

- 2.6.22 The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate turbidity and provide the option of displaying temperature if desired. The display shall be capable of displaying all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.
- 2.6.23 Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.
- 2.6.24 The instrument shall give measurements at an accuracy of $\pm 0.5\%$ of the measured value.
- 2.6.25 Ingress protection shall be IP65 as minimum.

Chlorine Analyser

- 2.6.26 Measurement of total free chlorine residual is important to allow chlorine dosing to be controlled to ensure that effluent is adequately dosed to ensure satisfactory disinfection but not excessively dosed which is wasteful of chemicals. Total free chlorine monitoring systems shall comprise a transducer, transmitter and interconnecting cable.
- 2.6.27 The transducer assembly shall comprise the sensor and any mounting hardware required. The system shall not require chemical reagents to make measurements. The sensor shall measure the concentration of free chlorine by amperometric principles. Total free chlorine shall be in the form of hypochlorous acid contained in the medium, which shall diffuse through the sensor membrane. Once inside the sensor, the hypochlorous acid is reduced to chloride ions (Cl^-) at the cathode, whilst at the anode, silver is oxidised to silver chloride. A current flow results from the electron release at the cathode and electron acceptance at the anode. The current flow is proportional to the total free chlorine concentration in the medium under constant conditions. The concentration of hypochlorous acid in the medium depends on the pH value. Accordingly, the sensor shall incorporate a pH sensor and the transmitter shall adjust the free chlorine measurement to compensate for pH. Cabling between the sensor and transmitter shall be easily disconnected from the sensor using a plug-in connector to allow quick and easy substitution of sensors in the event of a sensor failure.
- 2.6.28 The transmitter shall be microprocessor based and shall include an integral display and a simple push button user interface. The display shall indicate free chlorine residual and provide the option of displaying pH if desired. The display shall be capable of displaying

all error codes, process variables, configuration data and other internal values. Calibration shall be a simple procedure, requiring minimal operator input.

2.6.29 Input power required will be from a 24 VDC supply. An analogue output shall be provided along with a digital output to indicate fault status. The analogue output shall be by 4-20 mA current loop and shall be configurable to be proportional to the measured value or follow a user specified curve. Fault status shall be indicated by an open collector output, indicating system or sensor error.

2.6.30 The instrument shall give measurements at an accuracy of $\pm 0.5\%$ of the measured value and have quick response time. Drift shall be no greater than 1% of full scale per month, such that sensor recalibration shall not be a frequent requirement.

2.6.31 Ingress protection shall be IP65 as minimum.

H2S Analyser

2.6.32 Toxic gas detectors shall be capable of detecting H2S at ppm concentrations utilizing Smart electrochemical sensors.

2.6.33 The detector shall have a range of 0 to 50ppm H2S and shall operate using a 4 to 20 mA 24V DC HART loop. The detector shall be HART compliant, full maintenance diagnostics and configuration properties shall be available via a HART protocol signal overlaid onto the analogue signal. It shall possible to fully configure the transmitter via the hand held terminal or a suitable HART connection.

2.6.34 The transmitter unit shall have a GRP housing fitted with mounting brackets and rated IP65, certified EEx 'ia' IIC T5. The transmitter shall be fitted with a GRP EEx 'e' certified junction box and shall be suitable for use in ambient conditions.

2.6.35 A LCD on the measuring head shall continuously display the measured gas concentration. Adjustment of zero and span shall be carried out using the integral keyboard to enable one-man calibration in the field.

2.6.36 It shall be possible to carry out calibration without activating the field horns.

2.6.37 The detector shall offer the following standard features:

- Automatic sensor self-test;
- Easy configuration of measuring ranges;
- Remote (e.g. workshop) Pre Calibrated sensors;
- Full automatic electronic integrity test;
- Inbuilt maintenance diagnostics;
- Sensor sensitivity indication;
- End of sensor life pre-warning with countdown;
- Failsafe detection.

- 2.6.38 Fixed H2S monitoring shall be capable of providing 2 independent alarm settings (High and High-High).

2.7 Control Actuators

- 2.7.1 For control and on/off valves and penstocks, electric actuators shall be used.
- 2.7.2 Each control valve/penstock actuator shall include an inductive position transmitter with 4 – 20 mA output signal. This transmitter shall be protected from mechanical damage by a friction clutch.
- 2.7.3 Electric actuator enclosures with position transmitters and limit switches shall be provided with space heaters (if required) to maintain the inside temperature above dew point.
- 2.7.4 A hand wheel shall be provided for manual operation. Movement from motor operation to hand wheel operation shall be accomplished by a positive declutching knob, or lever, which will disengage the motor and motor gearing mechanically but not electrically. Provision of locking device for manual operation to prevent unauthorized operation of actuator shall be provided.
- 2.7.5 Actuators with servomotors shall have a self-locking characteristic in order to maintain its last position in case of switching off the motor or power failure against 120 % counter force/torque. If the motor is not fitted with a brake for these purposes, a gear box with a self-locking characteristic may be used.
- 2.7.6 All power gearing and rotary thrust conversion shall be oil or grease lubricated with an approved lubricant, which is suitable for at least four years' operation under the given ambient conditions.
- 2.7.7 All actuators for above ground service shall be of ingress protection class IP 65 and for the below ground service the ingress protection class shall be IP68.
- 2.7.8 All actuators are to be equipped with mechanical stops adjustable to the used travel range in order to prevent the actuator and the associated equipment from travelling past its normal range in the event that the limit switches fail to operate.
- 2.7.9 If the actuator design requires a switching off in the end positions, the actuator shall be equipped with a travel limit switch mechanism. If the actuator with these cut-off switches is proposed then a minimum of two switches, one for the closed position and one for the opened position shall be provided.
- 2.7.10 The electrical motor operated valve actuators shall be suitable for power supply at 415V $\pm 10\%$, 50 Hz $\pm 3\%$, 3 phase, unless specified otherwise in the data sheet.
- 2.7.11 Safety factor shall be 1.5% and 200% for general purpose and shutdown application respectively.
- 2.7.12 In case pneumatic control valves shall be used, they shall be supplied with spring return actuator, positioner and other accessories.

2.8 Instrument Cables

2.8.1 Signal cables shall be used for carrying low voltage, low power instrumentation signals between various field, plant and control room locations. In general, the signals shall be one of the following categories:

- Analogue 4-20 mA
- Digital 24V DC
- Resistance Temperature Detector
- Pulsed DC
- All cables shall be suitable for operation under the following conditions:
- Directly buried in ground
- Run in buried P.V.C., concrete or all steel ducts
- Runs fastened to cable tray in open air

2.8.2 Cables shall comply with BS EN 50288, Multi-elements metallic cables used in analogue and digital communication and protocol. Each cable shall consist of twisted pair or twisted triple conductors, with single pair or single triad having individual screen, and multipairs, multitriads collective and individual screen, together with drain wires, fillers, shielding, Armour and outer sheath as specified. Fire and Gas detector cables, if not 4-20mA signal cables, shall require overall shield only. The metric system shall be adopted throughout.

2.8.3 Sizes, lengths and other specific requirements of the cables shall be as indicated in the Request for Quotation and/or Purchase Order (RFQ/P.O.)

2.8.4 Thermocouple cables shall be in accordance with IEC 60584-3.

2.8.5 Conductor insulation shall be flame retardant Cross Linked polyethylene (XLPE).

2.8.6 The electrical characteristics C, L, and L/R ratios for intrinsically safe cables shall be in accordance with EN 50288.

2.8.7 The PVC outer sheath for all cables shall be anti-vermin impregnated, flame retardant to IEC 60332 Part 3 CAT 'A'. The oxygen index for the outside sheath shall be 30 (minimum). Type of compound inner/outer sheath to be A/ST1 of IEC 60502.

2.8.8 All intrinsically safe cables shall be manufactured with the overall PVC sheath colour Blue. Non I.S. cables shall have sheath coloured Black.

2.8.9 Each cable shall be identified by a 3-digit number which will be used throughout on all documentation prepared for the contract. This includes Block Diagrams, Loop Diagrams, Plant Layouts, Cable Schedules and Termination details if required. Each cable is to be prefaced with a designation letter to identify the duty and as follows:

P Power

C Control

M Metering

E Earthing

- 2.8.10 Numbering of cables for the identifier following the 'duty' prefixed letter is to be sequential in pre-designated groups. Similar numbers having different identifiers can be used. Each cable is to be identified on the Block Diagram with the number of cores contained in the cable. The number of cores shall be stated on the drawing adjacent to a diagonal line across the cable. Each core is to be double ferruled at the point of termination.

3. CONTROL AND AUTOMATION PANELS

3.1 Introduction

- 3.1.1 The STP and CEPT Plant monitoring, alarm and control shall be achieved via respective PLC control ICA panel and also remotely from the SCADA operator room at located at common area of the Plant.
- 3.1.2 A PLC based control system together with the HMI in each local ICA panel shall monitor and control its associated part of the plant, station equipment. SCADA system and ICA panels shall communicate with one another via a self-healing, fault tolerant and redundant communication network.
- 3.1.3 Contractor / vendor shall submit the overall system architecture with the bid.

3.2 Scope of Works

- 3.2.1 Contractor shall supply and install ICA panels with approved make PLC and HMI as per vendor list enclosed with the tender document. All other components shall be selected where practical from a single manufacturer's range. The vendor for ICA panel shall be subject to approval by Engineer/Owner.

3.3 Panel Type, Ingress Protection, Components and Enclosure Materials

- 3.3.1 ICA panel shall be Form 2 free standing, IP 54 suitable for indoor mounting. Panel depth shall be 800 mm. Painting - nanoceramic coating, electrophoretic dip followed by powder coating to RAL 7035.
- 3.3.2 All components shall be coordinated with the short circuit protective device such that a flow of current will cause no damage, and that normal operation of the equipment is unaffected.
- 3.3.3 Proper ventilation system shall be considered for each panel which will include G3 type EN 779 compliant Filter Fans and Louvers with IP 54 Ratings along with UL approved DIN Rail Mountable Hygro-thermostats. The panel's construction shall be such as to allow full accessibility from the front. Floor support and fixing bolts shall be provided by the contractor

- 3.3.4 The panel shall be sealed so as to be substantially dust proof. Cables shall enter and leave from the bottom. The panel shall be provided with a removable rustproof plated gland plate.
- 3.3.5 The Contractor shall provide and fit all necessary cable glands. Each cubicle of the panel shall be equipped with a fluorescent tube light interlocked with a door limit switch.
- 3.3.6 Control Panel shall have 20% free space for future expansion. Enclosure for Control ICA Panels shall be designed such that extensions can be made at either or both ends. The panel should be designed so that if required it may be split into sections for transportation bearing in mind the transportable weight. Each section is to be fitted with removable lifting eyebolts to facilitate handling. With transportation splits provision is to be made for any interconnecting wiring connections.
- 3.3.7 Enclosure shall be made from Multi folded frame of a single sheet with seamless 25 mm pitch all over the frame, with load carrying capacity of a maximum 1800 kg with option of door interchangeability, 180 Degree Hinge, special C fold in punch section, Clip-in holders and positioning aid for easier attachment and positioning of enclosure panels, PU foam gasket with sustainable IP throughout product life with single tool installation, enabled with e Pocket for ease of documentation. Laminated GI mounting plate without scratches having provision to get installed from outside frame. Enclosure with the following certifications – UL/ cUL/CSA/TÜV/Germanischer Bureau Veritas. The Height of instruments, switches, and indicators should be no more than a maximum of 1800 mm or less than a minimum 500 mm above the base of the panel assuming floor mounting unless otherwise specified.
- 3.3.8 Enclosure shall be sealed at cable entries with glands have IP56 protection degree. Gland plates shall not form part of the enclosure. Suitable cleats and supports shall be provided to ensure that cables are not supported by the cable glands.
- 3.3.9 All cabling shall be glanded directly in the section housing its terminals. Cabling between compartments shall be via termination chambers, and terminals shall be provided at the point at which the control panel are split for shipping.
- 3.3.10 All doors shall be earthed via flexible conductors. Every section of the panel shall be connected to the main earth bar. It shall be terminated in a separately mounted earth stud.
- 3.3.11 A continuous copper earth bar of not less than 25mm x 6mm cross section shall run the full length of each panel and shall be securely fixed and bonded electrically to the main frame. Control panels shall be completely wired to the terminals at the factory itself, requiring only connections to the external wiring circuits at site.
- 3.3.12 Extra electrical sockets for test and repair purposes shall be provided in the local ICA panels. These sockets shall be according to British Standards suitable for flat and round pins. Local ICA panels shall also have equipped with space heaters, if required.

- 3.3.13 The door shall have separate handle and locks. Each lock shall be provided with 2 keys. A document pocket containing a set of drawings and/or schedules shall be provided within the panel in an easily accessible position.
- 3.3.14 Components shall be mounted on a separate removable mounting plate. The only exception being front of panel mounted equipment.
- 3.3.15 Where removable covers exceed 1000 mm in height they shall be fitted with an engagement lip or similar to assist removal or replacement.
- 3.3.16 Internal wiring shall be adequately sized for the required voltages and currents. Cable ducts shall be provided with at least 20% spare capacity after complete wiring. Separate ducting shall be provided for the wires carrying different voltages.
- 3.3.17 ICA panels shall be of high standards quality in terms of visual appearance, colour, finish, smoothness of surface.
- 3.3.18 Labels shall be provided for all instruments, indication lamps, selector switches and push buttons installed in the panel door.
- 3.3.19 Titles on name plates shall be written in English. Materials for nameplates shall be selected in accordance with the weather data and area conditions and shall be of the non-metallic type, with black inscriptions on white background.
- 3.3.20 There shall be HMI with minimum display size of 15 inch (Refer to HMI specs in the below section).

3.4 Lightning Protection

- 3.4.1 An exposed cabling connecting to instrument located outdoors shall be provided with a lightning protection barrier at the point of ICA panel entry.

4. PROGRAMMABLE LOGIC CONTROLLER (PLC)

4.1 Introduction

- 4.1.1 This Specification covers minimum requirements of PLC as per approved vendor list which shall be used to monitor and control DPIA node STP and CETP Plant.

4.2 Scope of Works

- 4.2.1 The Contractor shall provide all assets associated with the programmable logic controller. This shall include all hardware and software items, including (but not limited to):
- 4.2.2 All hardware including equipment racks, central processor units, I/O cards, communications modules and programming cables.
- 4.2.3 All software including PC based configuration software (to include any “dongle”, license or other such software protection device required to utilize the software), fully documented and commented source code files.

- 4.2.4 All programming platforms (Development and Monitoring) and software for HMI, PLC and SCADA to be provided with a laptop for the same purpose.
- 4.2.5 The PLC shall be provided with sufficient communication ports to enable the laptop to be connected without a requirement to disconnect remote monitoring devices or any SCADA / HMI / programmable operator terminal units installed.

4.3 PLC Hardware Specifications

- 4.3.1 PLC system shall comprise of a central processing unit, input/output modules and serial interface modules. The PLC shall be of modular construction with plug in I/O cards and facility to install expansion racks/modules when necessary. The system shall include 20% spare capacity in hardware and memory for future modifications in addition to the I/O signals for future pumps.
- 4.3.2 PLC shall have dual redundant processor configuration. Over and above this, redundancies will be incorporated for input/output, power supply, communication network etc. Redundant I/O cards shall be used for closed loops, any other critical loop, shutdown and fire and gas loops.
- 4.3.3 The equipment shall accept discrete and analogue (4-20mA) signals from both field and panel mounted instruments. Analogue inputs shall be scanned into a 12 bit binary (minimum) analogue to digital converter with buffered inputs.
- 4.3.4 The PLC power supply shall be 230 VAC +/- 2% and 50 +/- 1% Hz UPS supply. The equipment shall be maintained in operation during a period of mains failure drawing power from the UPS system for a minimum back-up time of 3 hours. The UPS system shall include diagnostic and automatic self-test routines with volt-free contacts to initiate an alarm in the event of malfunction.
- 4.3.5 The PLC controller family shall have a high degree of interchange capability. The power supply, battery and EEPROM Chips should all operate equally well regardless of the CPU being used.
- 4.3.6 It should be possible that all assemblies and sub-assemblies performing similar functions shall be interchangeable.
- 4.3.7 The system design shall accommodate the replacement of assemblies without having to disconnect field wiring; removable connectors shall be used to connect field wiring to the individual circuit board assemblies.
- 4.3.8 All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings each of which indicates the manufacturer's catalogue number and item description.
- 4.3.9 The power supply unit shall be modular in design, compatible with main CPU and expansion racks allowing easy on-site replacement in the unlikely event of failure.

- 4.3.10 The power supply unit shall contain a battery compartment for installing a long life Lithium battery to protect programming CMOS RAM memory. The battery power transfer shall be bump less.
- 4.3.11 The battery shall be capable of supporting the memory for a period of minimum one year without having power applied to the system. The low battery condition shall be alarmed.
- 4.3.12 This battery shall be replaceable while power is applied to the PLC.
- 4.3.13 The user application program shall be stored in Random Access Memory (RAM) or a combination of RAM and Electronically Erasable and Programmable Read Only Memory (EEPROM).
- 4.3.14 The user application program scan time, on average, shall be no greater than 50ms for logic and integer processing. Where three terms control (PID) and Floating point data processing is required, the application scan time shall be no greater than 100ms.
- 4.3.15 RS232 Serial/Ethernet communication ports shall be provided to facilitate the following:
- a) Connect the laptop for PC compatible programming software
 - b) Connect the Hand-Held Programmer to the PLC
 - c) Connect to one of the wide variety of third-party operator interfaces utilizing an open architecture software protocol.
 - d) Provide RS-422 signals with RS-485 compatibility. The characteristics of this port shall be software configurable and shall be modem compatible.
- 4.3.16 When an I/O fault occurs, the processor shall report the location of the fault, the condition, the address and the circuit number If appropriate.
- 4.3.17 All digital input units shall be capable of accepting, a volt-free contact signal, the source voltage shall be regulated 24VDC and shall be derived from the PLC panel.
- 4.3.18 Where the input from an external source is not volt-free then suitable isolation devices shall be provided in order to prevent cross-connection of different supplies. This device may be e.g. interposing relay or optical-isolator. For frequencies of operation greater than 30 operations/hour, the use of electromechanical devices shall not be permitted. All interface/isolation devices shall provide visual indication of Signal State.
- 4.3.19 Inputs signals from 'DUTY' equipment shall not be allocated to the same input module as signals from 'STANDBY' equipment performing the same function.
- 4.3.20 Digital outputs used for AC inductive loads shall be fitted with arc suppression devices as close to the load as is practicable.
- 4.3.21 Provide hardware watchdog relays driven by digital outputs from the PLC to detect major PLC processor fault, I/O error and low battery fault.
- 4.3.22 PLC's to include facilities to retain the last state of the output modules at the time of the PLC failure. This shall be achieved by means of hardware or software.

- 4.3.23 The power (AC and DC) for I/O shall be distributed by the use of suitably rated MCB's. Separate MCB shall be provided for the followings:
- a) PLC and I/O rack power supplies.
 - b) External networking or communication if any.
 - c) Analogue DC power supplies.
 - d) Digital 24VDC power supplies.
 - e) Digital 230 VAC.
 - f) Digital 230 VAC.
- 4.3.24 The CPU shall have a memory protect key switch together with passwords to provide different levels of access privilege for the PLC when the programmer is in On-line.
- 4.3.25 Indication of status of digital I/O shall be provided by LED's on the face of the I/O module.
- 4.3.26 PLC shall be powered up from redundant ac to dc converter with mosfiet based O-ring with Power Boost 200% for 5 sec Permanent Power Boost 125% and shall have MTBF: >500000 hrs. at 40°C .
- 4.3.27 PLC shall comply to IEC 62443-4-2 for cyber security and shall be tested and in compliance with reputed 3rd party agency like KEMA, TUV etc. and shall have in-built firewall in it.
- 4.3.28 Type 3 Pluggable Surge Protection Device in accordance with IEC 61643 with KEMA & UL approval must be installed at the incoming power supply of PLC. DIN Rail Mounted Suitable Surge Protection must be installed on all communication lines (Ethernet/RS 485).
- 4.3.29 The processor unit shall have a real time clock with battery backup. A "battery low" indication lamp shall be provided to monitor battery status.

4.4 PLC Software Specifications

- 4.4.1 PLC Software shall be developed within the BS EN 61131-3 environment. Application program shall be developed by using software package that only conform to BS EN 61131-3 requirements.
- 4.4.2 Standard IEC libraries of Functions and Function Blocks shall be used when writing application software.
- 4.4.3 All software shall be suitably documented to include the following as a minimum:
- a) Suitable comments
 - b) Function description
 - c) Descriptions of all constants

d) List of cross-references

- 4.4.4 On-line and off-line, CPU and I/O configuration and application program development shall be achieved with a PC compatible computer and programming and documentation software.
- 4.4.5 The WINDOWS/ Windows NT Platform compatible software shall provide the capability of reading, writing, and verifying the configuration and program with a diskette / suitable backup arrangement.
- 4.4.6 The software shall provide on-line help information throughout its execution paths.
- 4.4.7 The software shall allow development of programming, storing the program to the PLC, monitor program and references address status while the PLC is in Run or Stop mode.
- 4.4.8 The software shall be user friendly to generate printout of the program for documentation purposes selectable to print various options e.g. printing of complete program with instruction for each rung, the reference list, reference description, reference address and tables.
- 4.4.9 The software shall have provisions for importing and exporting tag names, comments and descriptions in an .xls format
- 4.4.10 The programming language shall be BS EN 61131-3 compliant.
- 4.4.11 The CPU shall be capable of solving an application program whose source format shall be relay ladder diagram. The language shall support relay, timers and counters, arithmetic, relational, bit operation, data move, conversion, and control functions.
- 4.4.12 The CPU shall be capable of solving an application program whose main program format is in Sequential Function CHART (SFC) with underlying code in relay ladder diagram.
- 4.4.13 Control functions shall be provided to limit program execution, an immediate I/O update of all or a portion of the inputs or outputs for one scan while the program is running, or to update I/O during the program in addition to the normal I/O scan.
- 4.4.14 Additionally, the function shall provide a mean to read inputs into memory auxiliary to the true input table and execute outputs from discrete memory alternate to the true output table.
- 4.4.15 A method for structuring the ladder program shall be provided with the use of a JUMP Function. This will cause the program execution to jump to a specified location in the logic targeted by the location of the LABEL function.
- 4.4.16 Diagnostic and fault detection requirements shall typically include I/O data corruption, single bit RAM failures, power supply failures, processor failures, and I/O bus failures.
- 4.4.17 All PLC's shall be designed as hot standby and shall detect and report failures of all critical components so that appropriate control actions may be taken. All components that acquire or distribute I/O data or that are involved in execution of the control logic

solution are considered critical components. A fault in the active unit shall cause a switch of control to the backup unit.

Alarm System

- 4.4.18 The alarm system is part of the control system functions. The alarm systems shall contain all alarms for a safe and reliable operation of the pumping station. Alarms shall be generated when important operating data exceed their limits or when abnormal operating conditions occur in the pumping station. An accumulation of alarms, e.g. in case of system trips, must not cause any loss of alarms.
- 4.4.19 Alarms shall be initiated by means of position or limit switches, protection relays, fuses and miniature circuit-breakers, auxiliary contacts of switchgear, breakers, etc., or generated by the programmed digital system itself.
- 4.4.20 Tripping and auto-change over of motors, trip of circuit-breakers, status of isolation device, etc. shall be announced by flashing of the symbol on the HMI/SCADA operator station mimic diagram and on any related screen representation. Such trips shall also be announced on the alarm summary screen. In case of alarm, an acoustic signal shall be given. It can be cancelled by a horn-off acknowledgement pushbutton. The alarm acknowledgement push button shall be different from horn acknowledgement.

4.5 PLC Standards

- 4.5.1 PLC programming shall follow industry best practice. Software development shall be carried out in accordance with the methodologies described in BS EN 61508, BS EN 61511 and IEC 61131. Standard IEC libraries of Functions and Function Blocks shall be used when writing application software.

BS 7671 16th Edition	IEE Regulations for Electrical Installations
BS EN 60204	Safety of machinery
BS EN 61000	Electro-magnetic compatibility
BS EN 61131	Programmable Controllers
BS EN 50170	General purpose field communication system
ISBN 0 86341 233 5	IEE Guidelines for the documentation of computer software for real time and interactive systems
ISBN 0 11 883906 3	HSE Programmable Electronic Systems in safety related applications
BS EN 06200	Equivalent Standard to BS/EN, please refer to Division 6 Section Standards and Regulations (Guidelines)

4.6 Documents and Drawings

- 4.6.1 On contract stage and before handing over, the contractor shall submit comprehensive documentation (ISSUED FOR APPROVAL) including but not limited to:
1. PLC Program in hard copy as well soft copy.

2. Technical data sheets for PLC hardware.
3. Formal inspection and Functional test procedures
4. O&M manual and installation instruction.
5. I/O list.
6. Automation System Architecture.
7. GA drawing with BOM
8. Loop drawing
9. Heat load calculation
10. Power distribution
11. Wiring diagram
12. FAT / SAT Procedure

4.7 Spare Parts

- 4.7.1 Spare parts shall be provided as recommended by equipment manufacturers which shall be subject to review and approval by the Owner and Engineer.

4.8 Installation and Commissioning

- 4.8.1 The Contractor shall install and commission the supplied PLC. The Contractor shall provide the following:
1. Commissioning Plan
 2. Commissioning Manual
 3. Commissioning Log Test
 4. Documentation, schedules, logs and final status report.

4.9 Training

- 4.9.1 Training shall be provided at site for the Owner's O&M personnel for a week, either directly by manufacturer of various instruments and control systems or through their suppliers on operation, monitoring and control, maintenance of ICA equipment.

5. SCADA AND HMI

5.1 Introduction

- 5.1.1 This Specification covers minimum requirements of SCADA & HMI used to monitor and control DPIA node STP and CETP Plant (under EPC Tender Package B) in the network.

5.2 Scope of Works

- 5.2.1 STP and CETP Plant, flow metering, valve chambers and the lifting stations shall be monitored and controlled by SCADA system located at control room at common utility area.

- 5.2.2 The layout of the SCADA control room shall be proposed by the contractor for the Owner/Client's approval.
- 5.2.3 The Contractor shall provide all assets associated with the SCADA & HMI. This shall include all hardware and software items, including (but not limited to):
- All hardware including operator and engineering workstations, printers, servers, communication hardware and cables.
 - All software including PC based configuration software (to include any "dongle", license or other such software protection device required to utilize the software), fully documented and commented source code files.
 - All programming platforms (Development and Monitoring) and software for HMI, PLC and SCADA to be provided with a laptop for the same purpose.
- 5.2.4 SCADA System shall be installed in temperature controlled RCC Room with all the required furniture and filing cabinet. The operator workstation VDUs shall be located on the operator desk console.
- 5.2.5 To ensure high system availability, the SCADA equipment shall be configured in a dual redundant system configuration. The configuration of all proposed computers shall be of the latest revision at the time of the equipment supply and to the approval of the Employer's Representative.
- 5.2.6 One printer shall be color laser A3 printer provided for creating hard copies of workstation VDU. Other printer shall be a Dot Matrix type printer for Alarm/Event recording and for continuous logging of all pumping stations and entire plant data.
- 5.2.7 The SCADA software running on windows platform or latest industry proven version of Windows is preferred. The SCADA software shall have 'open system' client/server architecture allowing operation on and interfacing with a choice of hardware platforms. The SCADA software package shall be proven for similar application in India.

5.3 Standards

- 5.3.1 The following list of standards indicates the minimum requirements:
- | | |
|------------|---|
| IEC 60654 | Operating conditions for industrial process measurement and control equipment |
| IEC 60625 | Interface system for programmable measuring instruments |
| IEC 60902 | Industrial process measurement and control – terms and definitions |
| IEC 60839 | Alarm and warning systems |
| EN 50228 | Instrumentation cables |
| ISO 3511/1 | Process measurement control functions and instrumentation symbolic representation |
| BS 6739 | Instrument loop checkouts |

5.4 SCADA Computers

- 5.4.1 The SCADA computers shall provide the required power, flexibility and scalability for the required application under a true multi-user, multi-tasking environment, and shall comprise servers and operator workstations.
- 5.4.2 Work stations and servers shall be suitable and proven for the application.
- 5.4.3 Minimum two computers shall be used as workstations and shall be provided with Network Management software and industrial automation process software, to ensure high system availability. The SCADA computers shall be configured as fault tolerant dual redundant hot standby and shall be connected to the PLC system via dual communication sub-system.
- 5.4.4 Archiving system shall be provided which shall be based on magneto-optical storage technology. At least two archiving systems shall be provided, one for each workstation. In case one system failure, the other shall be capable of completely taking over the archiving function. Diagnostic software and historical file management, archival and retrieval shall be included.
- 5.4.5 The workstations shall have a screen diagonal measurement of at least 21" with a minimum resolution of 1600 x 1280 pixels and shall include tilt and swivel facilities. A full function industrial Modem Fax 65KB, keyboard and mouse/track ball unit shall be provided with each computer.
- 5.4.6 The computer hardware (RAID 1) proposed shall be from industry standard manufacturers, having permanent technical back-up and service facility available in INDIA, and shall be subjected to approval.
- 5.4.7 The SCADA computers shall be designed for non-obsolescence by allowing for sufficient future expansions, upgrades and enhancement in hardware and software including CPU, memory, hard disk, I/O hardware, and peripherals. The contractor shall provide the details of the expandability and upgrade path together with their tender proposal.

5.5 SCADA Printers

Printers shall conform to the following specifications. Manufacturer and type shall be best in the industry, and shall be subject to approval.

5.5.1 Page Printer

Information that is required on a page basis only, such as workstation colour graphical information and documents (but not for event-based information where each line represents an element of information) shall be printed using printers that print a page at a time. The printer shall have sufficient resolution to clearly print the smallest graphical and alphanumeric characters on A3/A4 paper format. Paper shall be hopper loaded.

Page printers shall be Colour Ink jet type and shall have the following minimum performance characteristics:

1. Throughput rate: six pages per minute (5% image area, text mode).
2. Printing resolution: 1440 dots per inch (dpi) at highest resolution (text and graphics mode).
3. Paper type: A4 and A3, plain paper, recycled quality or better.
4. Paper reserve capacity: 100 sheets minimum with manual-single-sheet feed facility.
5. Operating power requirements: 230V AC mains voltage/UPS.
6. Interval between services: 100,000 pages.
7. Data interfaces: Bi-directional Parallel Centronics (IEEE – 1284)
8. Print color: Multi color
9. Fonts: Adobe postscript fonts, and graphics and true type fonts.
10. Minimum range of fonts: CG Times; Times New Roman; Courier
11. Printing styles: Regular, bold, italic, underline, subscript/ superscript

5.5.2 Dot Matrix Printer

The Dot Matrix printer shall have the following minimum specification:

1. Bi-directional serial impact dot matrix printer.
2. 24 pin printing head, 80 or 136 column width depending on requirements.
3. Printing speed: 350 cps min in draft mode.
4. Paper handling: Plain paper, fan fold paper.
5. Paper feeding: Friction and fan fold paper tractor.
6. Interface: Bi-directional parallel Centronics (IEEE – 1284).
7. MTBF: 1000 hours minimum.

5.6 HMI Specification

- 5.6.1 Human Machine Interface Unit shall be provided for each local control panel/station.
- 5.6.2 HMI units shall have a backlit display with minimum display area of 15" with a minimum resolution of 256 pixels x 128 pixels and a wide viewing angle. Colour displays only acceptable. The unit shall incorporate touch VDU. Touch screens shall be divided into touch cells, with each cell rated for a minimum of 1,000,000 presses or more.
- 5.6.3 HMI units shall be powered by either a 230VAC or 24 VDC supply and shall have a power consumption of no greater than 100VA.

5.7 SCADA/HMI Design Concept

- 5.7.1 SCADA/HMI units shall be configured to display data in a logically ordered format allowing quick and easy access to measured variables. Where displaying all data in one view would result in a cluttered or confusing display or where viewing and entry of control set points is possible from the SCADA/HMI, there will be a requirement for a number of views. Where data is split up across a number of views in this manner, data

shall be displayed and accessed in a clear and logical way. The method used to switch between views shall be simple and intuitive. Periodic automatic scrolling of screens may be offered as an option but it shall be possible to disable this mode if desired.

- 5.7.2 The SCADA/HMI unit shall store its view configuration in non-volatile memory to enable normal operation to resume without operator intervention on resumption of power supply following an outage. A battery backed real-time clock shall be provided.
- 5.7.3 SCADA/HMIs shall be provided with a communication port to enable connection to the PLC for operational use.
- 5.7.4 Where the SCADA/HMI is used to view and enter control set points, it shall be necessary to enter a password via the numeric membrane keypad or via a touch screen representation of a numeric keypad (depending on hardware configuration). When the password is correctly entered, the new set point value may be entered. The entered value will be error checked to ensure that the entered value is within the acceptable range. If the value entered is acceptable, the operator shall be alerted that the set point has been accepted and the entered value shall be written to the relevant PLC register. If the value is outside the acceptable limits, the operator shall be alerted that the entered value is outside acceptable limits, the entered set point shall not be written to the PLC and the existing set point data shall be used.
- 5.7.5 Where a SCADA/HMI is supplied, the contractor shall provide all assets associated with the device. This shall include all hardware and software items, including (but not limited to):
- 5.7.6 All hardware including communications modules and programming cables.
- 5.7.7 All software including PC based configuration software (to include any “dongle”, license or other such software protection device required to utilize the software), fully documented and commented source code files.

5.8 SCADA/HMI Security System

- 5.8.1 Comprehensive security system shall be configured to ensure over all integrity of the control system. Three levels of security to be configured for the following persons:
- Operator (default)
 - Supervisor
 - Engineer
- 5.8.2 The system shall boot-up with operator security level. The following table shows the access of security groups.

Table 5-1 The Access of Security Groups

Name	Group 1	Group 2	Group 3
	Engineer	Supervisor	Operator
Default Password	ENGR	SUP	OPERATOR

View	✓	✓	✓
Application Shut down	✓		
Historical Trend	✓	✓	✓
System Configuration	✓		
Security	✓		
Alarm Summary Display	✓	✓	✓
Tag Group Editor	✓	✓	
Security Areas/ Function	✓		
Main Menu	✓	✓	✓
Control Override	✓	✓	
✓ - Access Allowed			

5.9 SCADA/HMI Graphic Screens

5.9.1 Each graphic screen should have as a minimum following property:

a) Header Section

Common top header on every screen shall provide access to the following:

- i. Main screen tab: shall open screen showing main sections of the pump station.
- ii. Alarm Summary
- iii. Log In
- iv. Log Out
- v. Screen Selection Tab: shall open a pop-up screen showing a list of screens. Operator can click on any button to display the relevant screen.
- vi. Screen description title
- vii. Date and Time

b) Footer Section

Common bottom footer on every screen shall provide access to the following:

- i. **Alarm Acknowledge:** By clicking on alarm acknowledge button from any screen, selected alarm should be acknowledged.
- ii. **Alarm Reset:** By clicking on alarm reset button from any screen selected alarm should be reset when only it is physically removed.

One-line alarm banner shall display the most recent alarm. If two alarms are raised simultaneously the alarm with higher priority should be displayed first.

5.10 Alarms Management System

5.10.1 All alarms shall be displayed / logged as a clear message indicating condition, time and date stamped.

- 5.10.2 Alarm Summary Screen: All alarms shall automatically send to the alarm summary page. Each alarm shall be time and date stamped. Colour coding shall be used to distinguish between (Alarm in alarm, and Alarm has been acknowledged).

5.11 Documents and Drawings

- 5.11.1 On contract stage and before handing over, the contractor shall submit comprehensive documentation (ISSUED FOR APPROVAL) including but not limited to:
- Colored hard copy of graphic screens.
 - Technical data sheets for SCADA/HMI hardware including servers & data loggers.
 - Alarm List.

5.12 Spares

- 5.12.1 Spares shall be provided as recommended by equipment manufacturer and it shall be submitted for review and approval by Owner and Engineer.

5.13 Installation and Commissioning

- 5.13.1 The Contractor shall install and commission the supplied SCADA/HMI system. The Contractor shall provide the following:
- Commissioning Plan
 - Commissioning Manual
 - Commissioning Log
 - Test Documentation, schedules, logs and final status report

5.14 Training

- 5.14.1 Training shall be provided at site for the Owner's O&M personnel for a week, either directly by manufacturer of various instruments and control systems or through their suppliers on operation, monitoring and control, maintenance of ICA equipment.

6. COMMUNICATION NETWORK

6.1 Introduction

- 6.1.1 The communication between local ICA panels and SCADA shall be via Ethernet protocol self-healing, redundant Network. The control system shall continuously monitor LAN communications and raise an alarm at the central HMI located at SCADA Room. If communications should fail between the central HMI and a controlling PLC or between PLCs if inter-PLC communication is being used. A separate SCADA screen (mimic) showing the real time status of PLC's, I/O modules, LAN communication etc. is to be incorporated.