OMAN WASTEWATER SERVICES COMPANY S.A.O.C

الشركة العمانية لخدمات الصرف الصحي ش.م.ع.م

OMAN WASTEWATER SERVICE COMPANY

TECHNICAL STANDARD SPECIFICATIONS FOR INSTRUMENTATION CONTROL & AUTOMATION

SECTION 05-03

PROGRAMMABLE LOGIC CONTROLLER

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1. SCOPE

The contractor shall supply PLC and LOI equipment as required by this specification.

2. DEFINITIONS

The following definitions shall be used for the purpose of interpreting this specification. Further definitions not contained in this section shall apply to the section in which they are stated and subsequent sections.

Programmable Logic Controller referred in text as "PLC" is defined as a single collection of; Central Processor Unit module (CPU), Power Supply modules, Input and Output modules, Communications modules connected in such a way to form a single logical unit capable of operation in isolation.

"PLC system" is defined as a single PLC or multiple PLC's that form the control system for the defined works.

"PLC module" or "module" is defined as a single constituent part of the PLC.

"PLC module bank" is defined as a collection of PLC modules inclusive of a power supply that form a single physical block. A PLC may be made from one or more PLC module blocks. (Previously known as Chassis, or Rack in rack mounted PLC systems.)

Input and Output is referred in text as "I/O".

"Process Control PLC" is defined as a PLC whose functionality is to control a functional area of the works. This PLC may communicate with other PLC's, Telemetry, SCADA, or in larger PLC systems with a "Data Gatherer PLC".

"Data Gatherer PLC" is defined as a PLC whose functionality is to solely collate data from "Process Control PLC's" for transfer to telemetry, and to forward telemetry command instructions to "Process Control PLC's".

Other Definitions

PLC	Programmable Logic Controller
CPU	Central Processor Unit
SCADA	Supervisory Control And Data Acquisition
FDS	Functional Design Specification
HAZOP	Hazards and Operability
RTU	Remote Transmission Unit

UPS	Uninterruptible Power Supply
MCC	Motor Control centre
LOI	Local Operator Interface
RCD	Residual Current Device
EEMPRON	Electronically Erasable Programmable Read Only Memory
HMI	Human Interface Machine
MCB	Miniature Circuit Breaker

3. REGULATIONS, SPECIFICATIONS AND STANDARDS

The design, construction, inspection and testing of the system shall comply with all relevant statutory Regulations, and the latest editions (current at the time of Tender) of all relevant British and Harmonised European Standards, including but not limited to:

- ISO/IEC 12207 - Information technology. Software life cycle processes
- BS ISO/IEC 6592 -Information technology. Guidelines for the documentation of computer-based application systems
- BS EN ISO 9000-3 - Quality management and quality assurance standards.

Guidelines for the application of ISO 9001:1994 to the development, supply, installation and maintenance of computer software

- BS IEC 61508 - Functional safety of electrical/electronic / programmable electronic safety-related systems
- IEC 61131 - Programmable controllers. (Formerly IEC 1131). All tools languages and programming shall be designed to conform to this standard
- BS EN 50081-1 Electromagnetic compatibility. 'Generic emission standard; residential, commercial and light industry
- BS EN 50082-1 Electromagnetic compatibility. Generic immunity standard; industrial environment
- BS EN 60801-2 Electromagnetic compatibility for industrial process measurement and control equipment. Electrostatic discharge requirements

4. SAFETY REQUIREMENTS

Systems and controls shall be organised, so far as reasonably practicable, to ensure that functions essential to the ultimate safety of plant and personnel are fail-safe, incorruptible and protected from the danger of hardware and software failures, or human errors.

Where possible, devices shall be chosen and software written where any failure would result in a fail-safe operation of the plant.

Failure to respond to proper and safe operating instructions shall automatically cause the appropriate control action to be initiated in order to:

a) Protect the safety of personnel

b) Protect the plant from physical damage

c) Adopt another control strategy to continue safe operations wherever possible. Plant sequences shall be programmed not to lock out unless to comply with conditions (a) and (b). Means of recovery shall not be enabled until such time as all hazards and faults are identified and rectified.

All safety instructions must be clearly defined in the Operating and Maintenance Manuals for the Works.

PLC equipment shall be chosen to meet the requirements set out by any HAZOP analysis undertaken either by or on behalf of the Employer prior to or during the design of the site.

5. GENERAL DESIGN REQUIREMENTS

Unless otherwise specified, new PLC's installed on works, where existing are in use, shall be compatible with existing systems, software and communication and network protocols.

The Contractor shall design and install the PLC system in line with the guidance and recommendations described within the manufacturer's literature.

The PLC shall interface with plant devices using digital and analogue input/output (I/O) cards and, where appropriate, field bus or serial communication cards all housed in one or more I/O chassis. The I/O cards shall be connected to field marshalling terminals using the manufacturer's proprietary I/O card connectors and cable harnesses.

The I/O cards shall provide appropriate noise reduction, status indication and appropriate isolation between the plant devices and the PLC.

The design shall be based on individually isolated outputs and inputs for digital and analogue signal types unless the contractor can demonstrate to the Engineer on a case by case basis that individual isolation is not required.

The maximum number of discrete inputs or outputs per card shall be 32, and each digital input and output shall be individually optically isolated.

Digital inputs shall be provided with volt-free contacts from field equipment, and shall be 'fail safe' in design; i.e. contacts opening upon alarm and with status conditions using normally open contacts. Digital input circuits shall be energised from the PLC.

Digital outputs shall provide either:

- A 24volt DC supply to energise a relay with a normally open relay contact suitably rated for the intended switching duty, or shall be the relay output type to drive field located equipment
- A 110V switching capability (either solid state or relay) to directly switch a control circuit located within the same MCC as the PLC

Analogue Output cards shall be of the, 4-20 mA DC current loop type, with a minimum conversion resolution of 12 bits. All analogue loops shall be cabled using twisted pairs in an overall screened multi-core cable with separation provided from power cables.

Analogue inputs shall be in the form of 4-20 mA DC current loops, with a maximum loop impedance not exceeding 250 ohms. Each analogue input loop shall be powered from its associated instrument where the instrument is mains powered, and from the PLC 24 V DC power supply where the instrument is loop powered. Critical loops shall be powered from their individual power supplies.

Analogue outputs shall be in the form of 4-20 mA DC current loops, shall be capable of driving into an impedance of between zero and 750 ohms, and shall have a direct connection to the load.

The need for isolated outputs (for Digital and Analogue inputs) will be assessed on a needs basis and specified by the contractor after consultation with the Engineer.

The PLC shall be installed within the Instrumentation, Control and Automation (ICA) section of a Motor Control Centre (MCC), unless agreed otherwise. A twin 230V AC 13 Amp BS 1363 metal clad socket with 30ma RCD protection shall be installed adjacent to the PLC.

The Contractor shall provide suitable surge protection for all power supplies, data signals, and field I/O signals susceptible to power surges and / or lightning induced voltages. Surge protection shall be fitted to all susceptible cabling which runs for greater than 10m outside of buildings. The clamp / protection voltage shall be selected to be the minimum possible commensurate with correct operation of the equipment being protected.

6. REMOTE ACCESS AND SUPPORT

The Contractor shall discuss with the Engineer the requirements for remote access and support and where required, provide all facilities to communicate remotely with the on site PLC systems.

7. TOPOLOGY TYPES

The general policy towards control systems topology and architecture will be as follows:

a) The preferred Control system shall utilise PLCs and operator interfaces, unless specified otherwise.

b) Where multiple PLCs are required they shall be networked and utilise a common communications protocol.

c) Where required the design shall include an Operator interface.

d) The Contractor shall design the PLC system topology to meet the requirements of:

- The policy defined above
- Requirements for system expansion capabilities detailed
- System Expansion
- Manufacturer's guidance literature
- Works conditions.

e) The Contractor's design shall be, where the size of the works requires, a robust distributed system of PLC's

f) The Contractor shall submit the PLC system topology design for the Engineer's approval prior to commencement of design

7.1. Single PLC

The Contractor shall base the PLC system design upon a single PLC topology where; the works functionality and I/O capacity may be achieved within a single PLC processor and associated I/O module banks, inclusive of PLC system expansion.

System Expansion, i.e. process control software and data gatherer software shall be contained within the single PLC processor.

Data Gatherer software is defined as the software which accomplishes the telemetry interface between the PLC system and the telemetry RTU. This software shall perform the function of streaming all telemetry data together to form an efficient telemetry data transfer system to and from the RTU.

7.2. Multiple PLCs

The Contractor shall base the PLC system design upon a robust distributed PLC system topology where; the works functionality and I/O capacity may not be achieved within a single PLC processor. The works functionality and I/O capacity shall include associated I/O module banks, inclusive of PLC system expansion as detailed in 22.10.12.

The Contractor's design shall include for a Data Gatherer PLC to process telemetry data to/from Process Control PLC's where the data requirements for telemetry would compromise a Process Control PLC also acting as Data Gatherer and would interfere with the primary process control functionality. Note that a separate Data Gatherer PLC is not required for a single PLC installation.

8. OPERATIONAL ENVIRONMENTAL REQUIREMENTS

The Contractor shall ensure that the installation is within the environmental tolerances of the PLC modules as defined in the manufacturer's literature. This shall include such considerations as, ambient temperature, relative humidity, atmospheric pollution,
altitude, vibration, mechanical shock, and power supply tolerances.

Additional forced air-cooling shall be supplied where recommended by the manufacturer, and be of the manufacturer's recommended type.

9. PLC LOCATION

The Contractor shall design the PLC installation to meet the manufacturer's
recommendations for installation, and inline with the following requirements.

The PLC modules shall be mounted within the ICA section of the MCC on a vertically mounted back-plate. PLCs shall be installed in MCCs in accordance with Section 17 of
the OWSC General Technical Specification such that access to mode selection switches and programming interface ports can be made safely whilst the system is operational.

PLC module banks shall use the DIN rail method of mounting detailed in the manufacturer's literature. The DIN rail shall be of the recommended size and type, with DIN rail length being sized to allow future expansion of the system as detailed in 22.10.12 System Expansion.

Adequate spacing must be left free around the PLC module banks to allow convection cooling inline with the recommendations of the manufacturer

PLC module banks shall be mounted horizontally, with separate banks being placed sequentially starting with the PLC module bank containing the processor. PLC module
banks may be placed side-by-side or vertically to suit the Contractor's panel design.

10. HARDWARE REQUIREMENTS

10.1. Suppliers and Components

The Contractor shall submit details on any modules and equipment to the Engineer for approval prior to use.

The Contractor shall design the PLC system to meet the details defined in the particular specification

It is the Contractor's responsibility to ensure all PLC modules selected are capable of forming a single fully functional PLC system meeting the requirements for I/O and control detailed in this specification, plus any additional I/O and control deemed necessary by the Contractor.

The contractor shall select additional electronic equipment and components other than PLC equipment from the appropriate sections of this specification.

10.2. Replication of Signals

Digital Signals entering the common control section or generated within the common control section, and requiring to be input into more than one device, shall be replicated by 24V DC interposing relays. The replicated signals shall then be routed individually to the relevant device, e.g.:

- The controlling PLC
- The telemetry outstation

The interposing relays shall be independent of any PLC.

Analogue signals shall be replicated by the use of analogue signals loop isolators. The loop isolator shall be selected to preserve the integrity of the analogue loop should any of the devices on the loop be disconnected. Replication shall not degrade the accuracy of the original signal to worse than 0.5% total.

10.3. Power Supply

All PLC and I/O panels shall operate on 24V ±10%, 50Hz ±2%.
The power (ac and dc) for I/O shall be distributed by the use of suitably rated terminal fuses or single-pole MCB's. One fuse shall be provided for each plant area or plant item and all I/O connected with the plant area or item shall be fed from this fuse. This shall ensure that a fault or malfunction in one plant area or item shall not affect another thereby causing the process to unnecessarily fail.

10.4. Processor Module (CPU)

The Contractor shall select the appropriate Processor Module that will achieve reliable control and communications functions whilst leaving adequate unused processor capacity to allow for future expansion of the PLC system.

10.5. System Expansion

The Contractor's choice of PLC processor module must ensure that CPU cycle times are sufficiently short to maintain proper control functions for the required plant functionality, whilst reserving enough system resources for communications.

The CPU shall be provided with an integral battery backup system capable of maintaining stored data for a minimum 6 months with no system power. Under normal plant operation the battery life expectancy shall exceed 2 years, when based on the expected power outages.

PLC battery status shall be monitored by SCADA, where there is no SCADA by HMI and in all cases by a signal connected to telemetry.

10.6. Real Time Clock

All PLC/Operator Interface Systems where plant processes are related to real-time, or where alarm/event logging is required, shall utilise a real-time clock.

The real-time clock shall have stability better than 0.001% per day.

The real-time clock shall be protected against mains failure for a minimum of 200 hours and shall continue to time for this period.

Where the PLC(s) are connected to an Operator Interface that also contains a real-time clock then the Operator Interface shall be the 'Master Timekeeper' and shall periodically synchronise the clock(s) within the PLC(s).

Where a system such as a SCADA system, resides at a higher level then this higher level system shall be the 'Master Timekeeper' and shall periodically synchronise the clock(s) within the Operator Interface(s) and PLC(s).

10.7. Program Memory

The PLC shall store the configuration in non-volatile retentive memory (EEPROM or Compact Flash).

The Contractor shall select the appropriate CPU memory capacity such that, at works take-over, there will be adequate unused memory to allow for future expansion of the.

The PLC shall reload the program from this non-volatile memory when reset.

10.8. Input / Output Modules

The contractor shall include additional expansion capacity. The Contractor's design shall logically group plant I/O signals based upon plant functionality. Signals of the same type associated with the same plant function or area shall be grouped together.

Where plant I/O signals relate to Duty / Standby equipment controlled by the PLC, the signals from the duty and standby shall be allocated to separate modules to reduce the possibility of total plant failure by a single I/O module failure.

The Contractor's design shall segregate differing voltage levels on separate I/O modules.

The Contractor shall use the appropriate isolated I/O card as indicated in the associated PLC Data Sheet Where an output is being used to control inductive devices the Contractor's design shall include an additional suppression device compliant with the manufacturer's recommendations and EMC regulations and Directives.

Interference suppression shall be employed across the windings of motors, which are started or stopped while the PLC is energised.

Only one output device shall be connected directly to any one PLC output module terminal.

I/O modules shall be provided with adequate cabling support to avoid strain on the termination headers. Means must be provided to prevent termination headers being accidentally disconnected. For each I/O module the header shall be clearly identified as to which module it relates.

Each wiring termination between I/O modules and incoming/outgoing terminals shall be identified with the relevant alphanumeric I/O address.

All inputs shall be "source" inputs e.g. 24V d.c. = 'input on', 0V d.c. = "input off" and all outputs shall be "source" outputs e.g. 'output on' = 24V ac, 'output off' = 0V ac.

All digital input units shall be capable of accepting:

(a) A volt-free contact signal, the source voltage shall be regulated 24V d.c. and shall be derived from the PLC panel and

(b) 15-18V d.c. inputs derived from external devices such as pulse outputs

(c) Where an 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 can be either on-board or a separately mounted device such as an interposing relay or opto-electronic isolator. For frequencies of operating greater than 30 operations/hour the use of electro-mechanical devices shall not be permitted. In all cases the device shall have visual indicators to show that the input is present.

Analogue inputs shall be either 1-5V dc. and feature high impedance characteristics (greater than 500kohms) or 4-20 mA d.c.

All PLC wiring shall be wired directly to separate terminal blocks in the panel.

All digital outputs shall be rated for the duty required and shall be selected from the following:

(a) Single pole normally open relay for 240V or 110V 2A and 0.5A 24V d.c. (b)

Triac (SCR) rated for 240V or 110V - 2A 50Hz

(c) Solid state output rated for 0.5A 24V d.c.

(d) Single pole change-over relay suitable for low current i.e. 5mA/24V d.c. Each output shall be totally volt-free

Note:

i) Where interposing relays for motor control etc are used then 24V d.c. outputs are preferred.

ii) Where a number of adjacent outputs are fed from a common supply then modules with groups of normally-open outputs with one or more common terminals are permitted, the common terminal(s) being connected to the common supply in question.

iii) Where outputs are for connection to interfaces or equipment supplied by others than the vendor then the outputs shall be totally isolated volt-free relay outputs suitably rated.

All outputs shall be rated, or suitably protected, to drive into a short- circuit and sustain an open- circuit for an indefinite period.

Standard analogue output signals shall be 4-20mA d.c.

Where not incorporated by the manufacturer d.c. output modules (24V) shall have back-emf diodes fitted, in the case of inductive loads, as close as possible to the output termination's or at the load (preferred).

Where not incorporated by the manufacturer a.c. output modules, where the load is inactive, shall have arc suppression or dV/dT protection circuitry fitted as close as possible, but not fitted, to the termination header.

Means shall be provided to allow the isolation of outputs causing unsafe movements or actions without removing power for the PLC Processor or inhibiting program execution.

The I/O wiring plastic trunking shall be installed so as to allow the spare I/O slots to be fully wired. The trunking should not be filled to greater than 60% after the spare slots have been utilised.

Sufficient spare terminal mounting rail shall be installed to allow the future wiring of the spare I/O modules to outgoing terminals.

All unused I/O on installed modules shall be terminated, to separate terminal blocks within the panel.

10.9. PLC I/O Marshalling

All PLC I/O (allocated and unallocated) shall be connected to knife disconnect marshalling terminals.
These terminals shall be mounted in the ICA compartment and located only at the "PLC end". The Contractor shall use a propriety pre-wired cabling system for interconnecting wiring between PLC I/O modules and the combined knife disconnect / marshalling terminals.

The marshalling shall provide all commons required by the PLC input and output modules for contact wetting. The Contractor shall allocate reserved terminal rail capacity, panel space and services to allow for additional marshalling requirements.

Unused analogue input signals shall be short circuited at these terminals if required by the PLC equipment. Prior to commissioning, the Contractor shall test that all marshalling terminals are connected to the correct digital and analogue I/O, and shall provide a dedicated drawing showing the terminals, reference numbers and descriptions

10.10. Digital Inputs and Outputs - Logic Sense

i. Digital Inputs

The sense of each digital input fed from a contact is listed below and that which shall apply when the condition is true:

INPUT DESIGNATION	CONTACT STATE	TELEMETRY LOGIC SENSE
DRIVE RUNNING	CONTACT CLOSED	1
DRIVE AVAILABLE	CONTACT CLOSED	1
DRIVE EM STOP ACTIVE	CONTACT OPEN	0
DRIVE EM STOP ACTIVE	CONTACT OPEN	0
VALVE FULLY OPEN	CONTACT CLOSED (OPEN WHILE VALVE IN TRANSIT OR CLOSED)	1
VALVE FULLY CLOSED	CONTACT CLOSED (OPEN WHILE VALVE IN TRANSIT OR OPEN)	1
VALVE AVAILABLE	CONTACT CLOSED	1
VALVE FAULT	CONTACT OPEN	0
PROTECTIVE DEVICE (SWITCH CLOSED)	CONTACT CLOSED	1
PROTECTIVE DEVICE TRIPPED ON FAULT	CONTACT OPEN	0
SYSTEM ON	CONTACT CLOSED	1
SYSTEM FAULT	CONTACT OPEN	0
Similar logic shall be applied to other similar types of signals		

ii. Digital Outputs

Each "run drive" digital output contact shall be open when the PLC does not require the drive to run and shall be closed when the PLC requires the drive to run. Each "open valve" digital output shall be normally open and shall close when the PLC requires the valve to open.

Each "close valve" digital output shall be normally open and shall close when the PLC requires the valve to close. Similar logic shall be applied to other similar types of signals.

10.11. Hardware Accessibility

All parts of the system(s) liable to failure, including power supplies, connectors etc, shall be readily accessible for the purposes of inspection and removal, without the need to dismantle and remove other components.

10.12. Communications

The Contractor shall supply, install and configure communication interfaces where connection to other control system components is required as part of the plant functionality or are defined in the associated PLC Data Sheet.

Communication interfaces shall be either integral to the processor module or by additional communications modules.

Sufficient communications interfaces shall be provided to allow the connection of a PLC programmer to a single PLC or PLC network simultaneously with all network communications fully connected and operational.

i. Control Network Communications (PLC Peer-to-Peer)

The Contractor shall supply, install and configure a data connection for peer to peer communications between PLC's, LOI, and onsite SCADA when required by the works functionality, Contractor's design, or where defined in the associated PLC Data Sheet.

The Contractor shall select one of the manufacturer's supported open standard or propriety protocols, based upon the manufacturer's guidance literature, and works conditions.

For plant networking the Contractor shall incorporate suitable network protocol such as TCP/IP or Ethernet /IP except where the protocol has be specified in the Particular Specification or where the PLC system is required to connect to an existing PLC network.

The Contractor's design shall take due regard of the manufacturer's recommendations with respect to network topology, number of nodes, cable lengths, and configuration.

ii. Profibus Devices

The Contractor shall supply, install and configure a Profibus network for PLC to Profibus devices when required by the works functionality, Contractor's design, or where defined in the associated particular specification.

The Contractor shall utilise the manufacturer's supported open standard protocol based upon the manufacturer's guidance literature, and works conditions; except, where an alternative Profibus protocol has been specified in the particular specification, or where the PLC system is required to connect to an existing Profibus network.

The Contractor's design shall take due regard of the manufacturer's recommendations with respect to network topology, number of nodes, cable lengths, and configuration.

iii. Package Plant Interfaces

The Contractor shall provide adequate data access to package plant as defined by the plant functional requirements. The default arrangements for data access is via hardwired digital and analogue signals

Where data communications are required the Contractor shall supply, install and configure network connectivity between PLC and Package Plant. Where supported by the relevant.

10.13. System Expansion

The Contractor's design shall ensure that, at works take-over, the PLC system is capable of being expanded by 20% (i.e. 20% of the total I/O.) or a minimum of two spare PLC module positions on a per PLC or remote I/O location basis.

Unused and unallocated I/O shall be fitted and wired to marshalling terminals. Such expansion capacity shall be designed to allow the later addition of PLC modules with the minimum disturbance to installed components and wiring.

Where the expansion provision cannot be achieved within the installed PLC module blocks, additional space and services shall be reserved for an additional PLC module block constituted of end caps, power supply, and 1 additional PLC module.

The Contractor shall produce for the Employer's use a PLC system expansion information sheet detailing where additional modules and panel services can be located.

10.14. External PLC Watchdog

The Contractor shall include in the PLC system design a hardware 'watchdog' for each PLC; the 'watchdog' shall perform the following function:

The 'main' program or module on the PLC shall output a pulse to reset a hardware timer

The watchdog timer shall provide a volt free contact, which shall close to indicate failure of the PLC program (i.e. the timer shall perform the function of a 'monostable', which is continually prevented from 'timing out' by resets from the PLC.)

The watchdog hardware may be a propriety item

The PLC reset pulse shall be provided by a solid-state device

The watchdog timer time out value shall not exceed a value of 5 seconds, unless otherwise specified or approved by the Engineer

The watchdog power supply shall be supplied from the same source as the PLC. When the PLC is running on mains supply the watchdog will run from mains also. When the PLC is being powered from standby supply the watchdog will be supplied from this same standby supply

The watchdog relay shall be monitored by the telemetry system. The relay shall also be configured to operate a red indicator lamp on the panel door of the PLC compartment. The lamp shall illuminate continuously when the watchdog has timed out and shall only be extinguished when the condition has cleared. It shall be clearly marked as to its purpose

10.15. Spares

Unless otherwise agreed the contractor shall additionally provide one complete set of each type of input, output and specialty card used on the project for spares.

11. SOFTWARE REQUIREMENTS

11.1. Standards for PLC Programming

The following general standards for programming shall apply. All PLC programs shall be designed and written to conform to IEC 61131-3 using the PLC manufacturer's standard programming software.

11.2. Program Format

All software shall be well structured, exhibiting a high degree of modularity. Software modules shall be functionally self-contained and independent of other software, with clear and well-defined interfaces with other modules.

Software modules shall comprise the minimum number of lines of code necessary to accomplish the module's intended purpose while still retaining legibility, and have single entry and exit points.

The use of nested sub-routines in software modules should be avoided. Sub-routines should have single entry and exit points and shall always return control to the calling program at the point-of-call. Non-standard programming techniques shall be avoided. Numbers, parameters or other fixed data shall not be embedded in software but rather in the database.

Databases and decision tables shall be fully normalised and structured to maximise processing speed and efficiency. Software shall be structured so that changes to one software component shall require little or no change to other components.

PLC application software and operating data shall be held in appropriate memory locations, secured against power failure. The contractor shall structure and document the PLC programs according to the standards defined in this specification.

Programs shall be written in accordance with the Standards for PLC Programming, but may include additional functions embedded within the manufacturer's programming package as standard. The Contractor shall select the most appropriate language based upon the functional requirements of the software. The Contractor shall ensure that no code shall be written unless the required functionality cannot be implemented by configuration of the supplied software packages. The Contractor shall develop all software, and systems configuration in a systematic, structured, and professional manner complying with the relevant requirements laid out in:

BS ISO/IEC 12207 **-** Information technology. Software life cycleprocesses

BS ISO/IEC 6592 **-**Information technology. Guidelines for the documentation of computer based application systems

BS EN ISO 9000-3 **-** Quality management and quality assurance standards. Guidelines for the application of ISO 9001:1994 to the development, supply, installation and maintenance of computer software

The Contractor shall ensure rigorous configuration management procedures, inclusive of version control, are adhered to throughout the project life cycle.

11.3. Naming Conventions

The Contractor shall use the naming convention as described in the particular specification to identify I/O points within the PLC. All PLC I/O shall be addressed within the software by reference to these names, and exclude actual dedicated I/O naming or addressing.

This naming convention shall be utilised by SCADA and telemetry also, to ensure a consistent naming convention from signal origin through all data acquisition equipment such as PLC, SCADA and telemetry thus ensuring that the same signal will have the same name in all systems

11.4. System Diagnostics

The contractor shall incorporate into the PLC program, a code module that calculates a checksum value for the PLC configuration stored in non-volatile memory each time the PLC is reset.

This checksum value shall be stored in a PLC register such that it is readable by works SCADA, LOI and Telemetry systems. The contractor shall incorporate into the PLC program, a code module that utilises the PLC system fault and diagnostic registers to produce information on the current PLC processor status.

11.5. Scaling of Analogue Values.

All analogues shall be scaled in the PLC using a standard code library to perform this function.

11.6. Set point Configuration

Where SCADA or LOI are provided, process set points (including variable process timers) shall be input via operator screens in engineering units. Conversion of set points into engineering units from raw analogue values shall take place in the PLC using a standard code library which shall be compliant with the requirements of Scaling of Analogue Values. Input range checking shall be performed by the PLC to ensure only valid set points are entered. Inputs shall be checked irrespective of the set point source (SCADA, LOI, telemetry etc.).

11.7. Generation of Alarms

The PLC shall detect internal erroneous or fault conditions and act upon them to place the control system in a safe predefined state. The PLC shall also bring this condition to the operator's attention through means of visual indication on site (i.e. operator interfaces, SCADA) and via telemetry for off site indication.

Each PLC forming part of a distributed networked plant control system shall have a stand alone operating capability, such that in the event of a network failure or disconnection. It shall be able to continue monitoring and controlling its associated plant using any set point and parameters available prior to any network failure, including the ability for operators to change set-points, duties, monitor alarms, etc. via the local operator interface.

The PLC application software controlling the plant shall be structured so as to provide as a minimum requirement, the following key functional areas.

11.8. Functional Area Software Routines

i. Plant initiation

This area shall contain routines developed to control plant start-up and restart, plant reset, and phased plant starting, after a power supply reenergisation, including a return to the control mode selected prior to powering down.

Plant trips, when reset by the operator, shall reinstate normal automatic operation without the need for further operator intervention. It should be noted that in order to meet the requirements of Operational efficiency, remote reset of trip conditions (via telemetry) shall be implemented.

ii. Plant automatic control

This area shall contain all software necessary to provide control of the plant processes and shall include alarm generation and exception handling, together with the starting-up and scheduling of any associated standby plant.

It should be noted that in order to meet the requirements of Operational efficiency, remote download of process set points (via telemetry) shall be implemented.

iii. Plant shutdown

This area shall contain routines developed to control plant shut down, including under operational power failure, and unplanned / emergency conditions.

iv. Operator and remote interface(s)

This area shall contain all software necessary to provide interfaces, where required, to a local Human Machine Interface (HMI/LOI), telemetry, and a Supervisory Control and Data Acquisition (SCADA) system.

All digital points to / from SCADA shall be held within separate integer files or memory areas, and analogue points to / from SCADA shall be held within separate floating point files or memory areas. In relation to the above, the PLC application software shall be developed to include, as a minimum, the following key requirements:

The selection of either hand off or automatic control for all plant items shall be provided, and the selected control mode displayed at the local LOI, and where provided, at a SCADA system. Where an item of plant is selected for hand control, the status of any associated plant shall remain unchanged

Direct operator control of all plant items available when a plant item is selected for automatic control, shall be provided at the local LOI and where provided, at a SCADA system. Where both SCADA and LOI are provided, the LOI shall display all information relevant to that local location; however the LOI shall adjust only those set points which are required to operate the plant under SCADA failure. The selection of direct control shall leave the plant item state unchanged until a new control command is issued

Where standby and / or assist plant is provided, the software control regime shall provide scheduling of these plant items through rotation of the duty, standby, and assist functions. The duty rotation shall be dependent either upon the hours run, or upon the issue of a manual duty rotate command. Duty shall normally rotate after the item of plant has stopped.

However, where items of plant do not stop then a duty rotation based on number of hours run shall take place. The required duty hours between zero and 99 shall be entered by the operator at the local LOI and where provided, via the SCADA system. (Note that where both SCADA and LOI are provided then only the SCADA need have this function). An entered value of zero duty hours shall inhibit the duty function within the associated plant item's duty rotation cycle.

11.9. Process Plant Safety Interlocks and Protection Devices

Safety interlocks for motors shall be hard-wired to the motor starter. These shall typically comprise emergency shutdown devices, flow monitor and run dry
protection, winding temperature monitor, over-pressure detectors for positive displacement pumps, etc. They shall operate fully in any mode and shall be independent of any PLC.

The hardwired safety interlock operation shall be wired also to the relevant area PLC in order to annunciate the fault at the SCADA (or LOIs where there is no SCADA), to remove the relevant motor run signal and carry out any other control functions dictated by the process control logic.

Safety interlocks shall also be provided to ensure that remotely downloaded set points or commands cannot cause damage to equipment or harm to personnel.

i. Protective Devices

Protective devices wired to the PLC shall be provided with suitable time delay functions to allow the system to stabilise before operation of the device. Safety critical protection shall operate immediately. Where a protective device has operated the drive shall be 'latched out', until the fault has been cleared and the latch manually reset.

An alarm shall be annunciated at the relevant starter and an alarm flag set within the area PLC. The LOI shall read the new value in the PLC and update the 'in use' set-point value on the screen.

ii. Hardwired Interlocking

Any drive stopped as a result of the action of a hardwired interlock or trip condition shall have its PLC run command output removed, and shall become unavailable for automatic control. Such interlocks shall be signaled as a drive fault. Drive Failed to Start / Stop Drive failed to Start / Stop alarms shall be implemented in the PLC for all drives that are operated under PLC control. The alarm detection condition shall only be active when the drive is available and selected for automatic control.

When a run command is sent to a drive, the PLC shall monitor the "Running" status at the drive, and if the drive fails to run, within a set time, e.g. 15 seconds, the drive shall be considered to be unavailable for automatic control. Under such circumstances a fault alarm shall be

generated, and standby plant shall take up the operational role, where available.

When a run command is revoked for a drive, the PLC shall monitor the "Running" status at the drive, and if the drive fails to stop, within a set time, e.g. 15 seconds, the drive shall be considered to be unavailable for automatic control. Under such circumstances a fault alarm shall be generated, and standby plant shall take up the operational role, where available.

The PLC shall routinely check that the drive status, for any drive in the automatic mode, is the same as the PLC command status, if not a fault alarm shall be generated. Note that this shall operate in conjunction with a de-bounce timer, whenever there is a change of state, to ensure that the drive has time to react to control requests.

The time intervals shall be set individually for each drive, according to process requirements. The settings shall be fixed in the PLC program and shall not be adjustable via LOI/SCADA.

11.10. Drive Operating Modes

i. Manual Mode

In manual mode the motor shall be controlled from the motor starter. It shall operate independently of the PLC controls.

ii. Automatic Mode

In automatic mode the drive shall be controlled by the dictates of the PLC. Manual control from the starter shall be disabled.

On transfer from manual to automatic mode a delay of ten seconds shall prevent any immediate start-up of the drive in automatic mode.

iii) Drive Availability

A drive shall be deemed 'available' for automatic control when:

- The starter mounted hand/off/auto selector switch is set to 'automatic'
- The emergency stop device is not operated
- The local isolator is 'on' i.e. "supply on"
- There is no drive fault;
- The drive has not been selected for SCADA manual control

The PLCs shall make an 'available' status bit for each drive available for monitoring by the SCADA system.

iv) SCADA Manual Control

SCADA manual control shall be implemented where there is a "geographic" spread of equipment, i.e. where there are multiple MCCs located in various buildings. SCADA manual control shall provide the same functionality as Manual but remotely via the SCADA system and PLC.

11.11. Typical Drive Function Blocks

The Contractor shall incorporate the following function blocks into the PLC programs, wherever relevant.

i. Drive Running Hours

A register shall be provided in the PLC logic to record the total running hours for each drive. Hours run counters need not be provided for small sump pumps or non process related drives. The register shall indicate the total running hours to the nearest completed hour and shall automatically reset to zero when the timer reaches 99999.

All hours run registers shall have configurable alarm set points, to highlight critical maintenance periods.

ii. Out of Range

Monitoring software shall be provided to generate 'out of range' alarms for all instruments, and to monitor instrument operation against related process signals, and where necessary generate appropriate discrepancy alarms.

Suitably selected timers shall be implemented to ensure that transient out of range conditions do not repeatedly generate out of range conditions. Range checking shall normally be performed by the PLC where SCADA, LOI and remote telemetry set points are provided.

iii. Wire Break detection

Wire break detection shall be implemented by detecting an analogue loop value of < 3.8mA for a period of 30 seconds. Wire break detection shall generate a SCADA/LOI under range alarm for the relevant signal .

Over range detection shall be implemented by detecting an analogue loop value of > 20.5mA for a period of 30 seconds. Over range detection shall generate a SCADA/LOI over range alarm for the relevant signal.

iv.Rate of Change

Monitoring software shall be provided to generate 'rate of change' alarms where required (by the Employer) to monitor instrument operation against related process signals, and where necessary, generate appropriate discrepancy alarms.

v.Drive Duty Rotation

Framework suppliers to develop standard code library for the following functions.

vi.General

This section generally refers to drives, as these are the devices normally affected by duty / standby, or duty / assist / standby, selection, rotation and changeover.

The facility shall be provided for drives that are in duty/standby pairs, or in multiple duty groups, which require manual or automatic duty/assist/standby selection and rotation.

Where a drive is unavailable for duty selection, although selected for use, the PLC shall utilise the next available drive, or where there is only a single pair of drives, the PLC shall continue operation with any available drive.

vii. Duty / Assist / Standby Rotation

i) Drive Selection

Where duty/assist/standby selection is manual only, the PLC shall accept signals from the LOI/SCADA, or selector switches, to determine the required duty/assist/standby. The status of the selections shall be displayed at the LOI/SCADA.

Multiple drive systems, which are controlled via the PLC, shall be provided with a means to select the preferred duty/assist/standby configuration, or to select automatic rotation of the drives. This shall either be selected by means of a rotary switch at the control panel, or through the LOI/SCADA. Note rotary switches shall only be considered, where no LOI/SCADA is provided, or otherwise specified.

Where a selector switch is used to select the required drive

configuration, to prevent drives from starting and stopping as switch is rotated, the selection shall be provided with a time delay, to allow the operator to rotate the switch to the required position. Only after the timer has expired will the new duty/assist/standby configuration be

accepted. Likewise, when selecting a preferred drive configuration through the LOI/SCADA.

A standby or other available drive shall replace drives that are unavailable for automatic control. An alarm flag shall be raised for any drive unavailable for automatic control.

ii) Automatic Rotation

Drives selected for automatic Duty/Assist/Standby Rotation shall normally rotate each time the selected duty drive stops, or where drives would not normally stop, at an appropriate time to prevent process upset.

iii) Automatic Time Elapsed Rotation

When specifically detailed, automatic time elapsed rotation shall be implemented for drives in a multiple drive groups. This mode of duty rotation shall be employed to ensure that the drives in a group are utilised equally where (typically) one drive would otherwise run continuously (ventilation fans, dosing pumps etc.).

Where time elapsed rotation is used; this shall be provided in addition to manual duty selection. When the selection "Time Elapse Rotation" is made via LOI/SCADA, the PLC shall rotate the duty selection each time the Time Elapsed Rotation timer expires.

During operation of the time elapsed rotation system, any manual duty allocation made shall not have any influence on the order in which the drives are started (ie. all drives will have equal status). Where the operation of plant items is determined by upper and lower process limits, the automatic changeover of duty status shall be delayed until an appropriate point within the operating cycle.

iv) Fault Rotation

For plant configurations which incorporate a standby drive, the standby drive shall, unless specified otherwise, start automatically to replace a failed duty drive.

The standby drive can continue running until it is next called to stop by the process. Once the fault has been cleared (manually) the duty drive will start when that duty is next called to run by the process.

viii. Actuator Failed to Open / Close

This section shall apply only to valve actuators that operate in either the fully open or fully closed positions. It shall not apply to actuators that are used for valve position control.

Actuator failed to Open/Close alarms shall be implemented in the PLC for all motorised actuators that can be operated under PLC control. The alarm detection

condition shall be active when the actuator is available and is selected to for automatic control. When an open command is sent to an actuator, the PLC shall monitor the "Open" status, and if the actuator fails to open, within a set time, e.g. 120 seconds, the actuator shall be considered to be unavailable for automatic control. Under such circumstances a fault alarm shall be generated, and standby plant shall take up the operational role, where available.

When a close command is sent to an actuator, the PLC shall monitor the "Closed" status, and if the actuator fails to close, within a set time, e.g. 120 seconds, the drive shall be considered to be unavailable for automatic control. Under such circumstances a fault alarm shall be generated, and standby plant shall take up the operational role, where available.

Once an actuator has reached its end of travel and the travel timer has been disengaged, the "Failed to Open/Close" alarm shall be disabled until a new command is issued.

The time intervals shall be set individually for each actuator, according to its expected travel time. A typical setting would be 125% of the time normally taken by the actuator to move from one end of travel to the other.

The settings shall be fixed in the PLC program and shall not be adjustable via LOI/SCADA. Discuss with framework suppliers as to whether these variables should be operator configurable.

ix. PID Controllers

Proportional, integral and differential (PID) algorithms, or three term controllers, may be used for various control functions. PLC Functions for this purpose shall be used rather than discreet standalone controllers.

The PLC shall make available for interrogation and display by the SCADA the proportional, integral and differential gains, the set-point value and the offset value, if used, for each PID controller and the controlled variable.

The Employer (in the form of "Engineer level access") shall be able to select new values for each of these parameters and these shall be displayed by the SCADA alongside the existing values in the PLC. When the operator confirms that he wishes the new values to be implemented, the SCADA shall first check the values for validity and then send them to the PLC where they shall overwrite the previous values. The SCADA shall read the new value in the PLC and update the 'in use' value of the parameter on the screen.

To assist with the tuning process, the PLC shall also make available for display by the SCADA the process variable PV value and the PID controller output OP value.

11.12. De-bounce Timers and Damping

Digital Signals

Digital signals from level probes float switches, etc, that are subject to

fluctuation and spurious operation shall be conditioned within the PLC, or the measuring device, before being applied to logical control functions. Input shall remain on, for an appropriate period of time, before being accepted. Input shall remain off, for an appropriate period of time, before being accepted.

11.13. Analogue Set-points

All process set-points shall be operator configurable. When the operator confirms that the new value shall be implemented, an input range check shall be performed to validate the new value.

To be valid, a new set-point must fulfill all the following requirements:

Be equal to or greater than the minimum permissible value

Be equal to or less than the maximum permissible value

If the new value is valid, it shall be accepted as the new set-point. Existing setpoints shall not be overwritten until the new values are accepted as valid.

The LOI/SCADA shall read the new value back from the PLC and update the “in use” set-point value on the screen.

11.14. Default Values

Every set-point or other parameter which is operator-selectable via LOI/SCADA or telemetry remote set point shall have in the PLC program a default value.

The default value shall be used if no other value has been entered, or if the value previously entered by use of LOI/SCADA/telemetry has been lost (e.g. due to loss of power or other shut-down of the PLC). Where LOI and or SCADA systems are provided as part of the PLC system, indication shall be provided to show what the default value is and if it is in use.

Sensible and logical default values shall be inserted prior to the start of system tests. The default values at the time of handing over the plant shall be those found operationally suitable during commissioning. It should be noted that set points, calculated values and all other operator input values etc shall be stored in non volatile memory in the PLC.

These values shall always be read by the LOI/SCADA/Telemetry. Should an LOI/SCADA unit be replaced/cold started etc, all values shall be read out of the PLC to

be displayed on LOI/SCADA/Telemetry etc.

11.15. Signal Integration

Wherever the LOI/SCADA requires a parameter which has to be derived from integrating signals, the integration shall be carried out in the PLC.

12. DOCUMENTATION

12.1. Design Submissions

All software produced or modified by the Contractor shall be subject to the following formal documentation and approval stages, and contain:

Control Philosophy
Functional Design Specification (FDS)
Software Test Plan Document (FAT / SAT)
Software Code (forming part of the as-built documentation)

Preparation / coding of software shall not commence prior to the Engineer's approval of the FDS.

12.2. Control Philosophy

The contractor shall discuss with the Engineer methods of achieving automatic control, of the Works to comply with the specification. In general the Employer will wish to adopt the simplest control solutions and unless otherwise specified this may be a Programmable Logic Controller System to carry out the process plant control sequences and the collection of data from field equipment and devices. The Control Philosophy shall include but be not limited to a description of the following:

General Control methodology (outline of control algorithm)
Performance to be achieved
Definition of input and output signals, internal PLC signals to be used
Reference to the Employer's requirements

12.3. Functional Design Specification

The Contractor shall develop the PLC Functional Design Specification. This document shall fully describe, using logic diagrams, tables etc as necessary, and the manner in which the process is to be controlled to achieve the requirements of the specification and process requirements.

It shall include detailed equipment and device references, their interaction, (stop, start, fail etc) and levels of such as alarms, set points and engineering ranges.

Full and detailed references shall also be made with respect to the functionality of LOI or SCADA devices and any interactions required by operations or engineering personnel. A cross reference to the Employer's requirements shall be provided. I/O schedules shall be provided according to the typical template as attached Appendix 3. Appendix 4 is to be developed with the framework suppliers

12.4. Software Tests

The Contractor shall perform system testing in line with thePLC Acceptance Tests and Test Documentation

12.5. Software Copyright

The Contractor shall transfer to the Employer, at works take-over, all intellectual rights to software and configuration written to meet the requirements of these works.

The Contractor shall transfer to the Employer, at works take-over, all required software licences and installation media for third party products required to meet the requirements of the works.

12.6. Design Documentation Submissions

All design documentation shall be submitted as a single electronic copy for approval

12.7. As Built Documentation Submissions

An electronic copy of the final commissioned as built application software (including LOI and PLC etc applications shall be provided. Note - Hard copies of the application code documentation, FDS, FAT and SAT are required as part of each copy of the Operation and Maintenance manuals.

13. PLC ACCEPTANCE TESTS AND DOCUMENTATION

Note - Test documentation may be integrated with the FDS.

13.1. PLC Acceptance Tests

The Contractor shall provide the Engineer with a Factory Acceptance Test (FAT) document and a Site Acceptance test (SAT) document, which comprehensively describes PLC tests to be carried out at the Manufacturers' works and on site.

These documents shall provide a detailed step by step set of instructions to perform the tests which clearly show for each test: the initial conditions, the function/test to be performed, the expected outcome of the test, and the cross references to the requirements documents. Pass / fail and comments fields are required for each test. A cause and effect diagram of the type shown in Appendix 2 shall also be used.

The test documents shall demonstrate that the Software will control the process plant as described in the Employer's Requirements Documents / specification, Functional Design Specification and Software Design Specification The Contractor shall submit 2 copies of the proposed test sheets and test documents to the Engineer for approval at least 21 days prior to the tests being carried out. One copy of the completed test sheets shall be submitted to the Engineer within 7 days of any tests being completed. All completed test sheets shall be included in the Operation and Maintenance Manuals.

The Contractor shall provide all necessary labour, tools, materials, equipment, etc. required to carry out all tests. The Contractor shall carry out the following tests in addition to any other tests stated or implied in the specification. Such tests shall not release the Contractor from any obligation under the Contract.

13.2. Factory Acceptance Test (FAT)

The Contractor shall test the PLC software on the fully assembled Motor Control Centre/ICA Panel, at the Manufacturers' works, prior to delivery of the Motor Control Centre to site.

The PLC programmes shall be tested using a suitable test system to simulate all, digital and analogue, input and output signals. Using the test system it shall be possible to fully simulate the operation of the process plant and equipment. The simulation may be achieved using either hardware or software test equipment.

The Contractor shall simulate the process sequences and associated fault routines, as detailed in the specification and approved Functional Design Specifications. The tests shall be deemed to have failed if the Contractor fails to demonstrate that the PLC will control the process plant as required by the specification and in accordance with the approved Functional Descriptions.

Tests shall include as a minimum:

Simulation testing of the "normal process"

Simulation testing of the fault routines and automatic plant start up following a total power failure. Total power failure shall mean failure of all mains and standby power sources, including generator and UPS systems

Testing of disaster recovery where the PLC/LOI require the PLC / LOI program to be reloaded from PLC/LOI Programmer

Testing of the reloading of program in the PLC/LOI from non volatile program memory on reset

13.3. Site Acceptance Test (SAT)

The SAT shall only be performed after successful FAT. The SAT document

shall be based on the FAT document The Contractor shall simulate the process sequences, and associated fault routines, as detailed in the Employer's requirements/specification and approved functional and Design Specifications. Following successful simulation of the process sequences, and on completion of the commissioning tests, the plant shall be tested to operate correctly in the 'live' environment. All inputs to the PLC shall be made through the field terminal connections of the Motor Control Centre. The tests shall be deemed to have failed if:

The Contractor fails to demonstrate that the PLC will control the process plant as required by this specification and in accordance with the Functional Descriptions. OR

The contractor fails to demonstrate that the plant works in the manual and automatic modes as described in the FDS

Tests shall include as a minimum:

Testing of the "normal process" i.e. the performance of the works as a whole

Testing of the fault routines and automatic plant start up following a total power failure

Total power failure shall mean failure of all mains and standby power sources, including generator and UPS systems

Testing of disaster recovery where the PLC/LOI require the program to be reloaded from PLC Programmer

Testing of the reloading of program in the PLC/LOI from non volatile program memory on reset

14. LOCAL OPERATOR INTERFACE (LOI)

14.1. LOI Philosophy

The LOI is determined to be the main method of viewing and controlling the process. The need for mimic trending and logging capability shall be as specified in the particular specification. Local LOIs (where there is a demonstrated need, rather than a central LOI) shall be used to:

Display relevant local information (e.g. plant status, process status, trending / logging)

Provide minimum control functions (e.g. set point adjustment) to allow control of the local plant and process in the event of SCADA failure

Provide local plant control to perform maintenance. E.g. run / stop of plant

14.2. PARTICULAR REQUIREMENTS FOR LOI

The contractor shall, use the manufacturer's proprietary configuration software to define the mimics and tabular displays. The mimics and tabular displays shall where appropriate be consistent with the site SCADA system, taking into account, but not limited to, the following attributes of each system:

Direction of flow
Row headings
Mimic naming conventions
Plant naming conventions
Colours (where colour LOI is used)
Symbols
Control functions
Trending (where the selection guide requires logging/trending to be used)

The contractor shall configure screens to cover the entire plant associated with the PLC'S accessed by the particular LOI. One screen page shall show a block diagram process overview of the whole plant (two pages may be used only where the plant is too large to fit on a single page).

Minimum screen size shall be 17" unless otherwise stated in the Particular Specification.

The plant shall be broken up into logical areas with at least one screen page per area. Each screen shall show all controlled and monitored plant within the area that it covers.

In general, where an LOI with mimic capability is used the mimic shall resemble the P&I diagram.

Unmonitored or uncontrolled plant shall be shown, where a contribution to the process is made by this plant.

All plant shown shall have its tag number displayed on screen as close as practicable to the plant item icon.

All numerical variables shall have the unit of measure next to the number.

The operator shall be able to move between mimic pages by two methods, either by directly selecting the page from the overview graphic or by navigating through the plant using graphical buttons on the input or output links of mimic pages. These buttons shall clearly show in graphics or text the screen that will be selected if the button is pressed.

Mimics pages shall be of 2 distinct types: process pages (chained from the Main Menu Overview Screen) or system and diagnostic pages where appropriate (chained from the System Menu Overview Screen).

The contractor shall not locate his company name or logo or any other form of advertising on any of the mimic screens. The contractor's name, contact details and software version number shall be located on the start up screen.

The engineering units associated with each reported value on the mimic shall be displayed beside the value.

The contractor shall ensure that each mimic or tabular display within the LOI is designed to ensure the efficient operation of the PLC and shall, where possible, display groups of I/O objects which can be "packed" together to provide the most efficient polling of the PLC.

The number of live data objects defined within each mimic shall be designed to provide both efficient operation of the PLC, and efficient memory usage of the LOI.

14.3. LOI Screen Access and Navigation

The following paragraphs describe the generic functions required.

i. Status Screens

Status screens shall display:

- The status of the plant
- Highest unacknowledged alarm priority
- Screen identification number (mimic LOI)

Data entry and configuration shall not be allowed.

ii. Control Screens

These shall be used for plant control and configuration. Each

screen shall display:

- Screen identification number (mimic LOI)
- Highest unacknowledged alarm priority

iii. Set point Screens

Set point screens shall display the plant set points: a description of the set point, its current value, the unit of measure and a data entry field.

All set point numeric entry boxes shall have upper and lower limits set to the plant upper and lower limit set points to prohibit entry of set points outside the allowable limits. The range checking function shall be
performed by the PLC.

An “execute” or similar function key shall be used to indicate to the PLC that this value shall now be used as the current set point value.

iv. Selection of Duty/Standby Plant

Where the PLC controls Duty / Standby plant modes of operation, screens shall display the duty standby settings of the plant and shall enable the operator to change the duty rotation, select auto rotation and change the auto duty rotation timer if applicable.

v. Motor Hours Run Timers Screen

This shall be a single tabular screen displaying the hours ran for each motor in hours and shall indicate the total running hours to the nearest completed hour and shall automatically reset to zero when the timer reaches 99999.

vi. Passwords

Passwords shall not be required to view any screen.
There shall be two LOI passwords (operator and developer), hard-coded into the PLC ladder code. No facility shall exist for it to be changed via the LOI.

The operator password shall be entered on the start-up screen to allow the operator to enter data for use by the PLC.

When a valid operator password has been entered a timer shall be started in the PLC. After one (1) hour this timer shall time out.

On timing out the PLC shall log off the LOI and set the screen to the main menu.

This function shall prevent control data being changed until the password is re-entered, however, all status data shall still be accessible.

The password level shall be displayed on each screen.

The contractor shall implement the passwords defined by the Employer. These shall be defined during the design phase.

14.4. Screen Configuration

i) Start Up Screen

This screen shall display the following:

Time and Date (time and date shall be displayed on all screens)
The Site Name
Password level
Contractors contact details software revision
Function Key to Select Main Menu

ii) Main Menu

This screen shall provide the main access to project specific screens at a lower level in the hierarchy. Access to actual screens shall be via function keys, with a table detailing the options available.

The following options shall be included, where appropriate:

Status
Control
Set points
Duty standby
Motor hours run timers
Alarms
Trends

Status and control options may be incorporated into a single screen. Where each of status and control shall be separately selected via a sub menu in table format.

iii) LOI CONFIGURATION (SCREEN)

Standard LOI settings shall be developed and defined in this section.

The following are examples of settings to be defined:

Bytes used
LOI fault status
Backlight
Node address
Baud Rate
Screen saver mode
Date time settings

Download configuration settings
System language Function Keys

iv) Function Key Allocation

Standard Function keys shall be defined for controlling screen navigation. The Contractor shall develop standard function key allocations.

The allocation shall ensure that the function keys are defined according to the Employer's standard requirements as defined within this specification

All other function keys except the keys detailed below shall be used for PLC control. On mimic LOIs a box shall be drawn at the bottom of the screen above the function key. The box shall contain text describing the button's function. If the button is of a maintained type two text descriptions shall be used to describe each function.

The following function keys are reserved for all screens and shall not be used for any other purpose:

F6:Help
F7:Next screen
F8:Previous Screen
F9:Alarm summary
F10: Main Menu (start up screen)

v) Alarms

General

The contractor shall ensure that the LOI is configured to display and accept alarms as follows:

An alarm summary approach shall be used, i.e. all alarms shall be shown on a single screen with highest priority alarm located first;
Three priorities shall be used: Priority 1 (P1), Priority 2 (P2) and Priority 3 (P3), Priority 1 shall be the highest priority. The contractor in conjunction with the Engineer shall define the priority for each alarm. This shall be recorded in the FDS;
All status and control screens shall indicate the highest priority of unacknowledged alarm in the alarm summary;
The operator user shall be able to acknowledge all alarms (all at once).
Acknowledgement of the alarm shall silence the LOI alarm (and thePLC driven works alarm sounder as if acknowledged by SCADA) and stop the alarm text blinking on the LOI
Alarms shall activate the audio signal on the LOI
Alarms shall blink when in alarm
Alarm messages shall only be cleared from the alarm summary by the

PLC, if the alarm has been acknowledged by the Operator and the source of the alarm has been removed, e.g. a tripped drive has been repaired and reset manually

On LOIs, as a minimum, the alarm messages shall contain the I/O tag name, the I/O point name, the text status

Priority, Time and Date. Note that on colour LOIs priority shall be indicated by different colours for different priorities of alarm.

LOI Configuration (Alarm)

Standard LOI settings shall be developed and defined in this section. The following are examples of settings to be defined:

All objects displayed - Yes
Clear history on power up - No
Size - 100
Ack. hold time - 500 ms
Use optional fields - Yes

Alarm Acknowledgement

The alarm acknowledge button shall be assigned to a function key.

LOI Configuration (Alarm History)

Standard LOI settings shall be developed and defined in this section. The following are examples of settings to be defined:

Alarm date - Yes
Alarm time - Yes
Acknowledge date - Yes
Acknowledge time - Yes
Alarm trigger value - No
Text size: 6 x 8
Lines per alarm: 1
Wraparound - Yes

Testing and Test Documentation

LOI test documentation shall include but be not limited to:

Screen shots
navigation map
set point limits
LOI Test Results

14.5. Software Supply

All software shall be supplied on CD ROM. LOI files shall include a Tag database export in comma separated variable (CSV) format