City of London

Environmental Services

Consolidated

AUTOMATION AND CONTROL
VOLUME 3
PROGRAMMING REQUIREMENTS

Version 4.1

INDEX

Version	Date	Description of Revisions
3.9	04/12/02	Preliminary release of consolidated requirements
4.0a	10/07/08	Updates (Stantec, Sergio Stevandic, 2008-07-10)
4.0b	13/08/08	Updated to meet current system standard.
4.1	09/03/09	Web site release

PART 1 INTRODUCTION

1.01 Common

(a) General

The requirements set forth within this document, and related documents, define the minimum requirements acceptable to the City of London.

All applications are in the environment of water distribution, wastewater collection and wastewater treatment facilities. Thus, the environment is harsh, possibly prone to hydrogen sulphide contamination in the air and high condensing humidity (resulting in mild sulphuric acid precipitants) and/or low levels of free chlorine.

Allowable deviations shall be specifically and categorically stated within the tender package (or request for proposal).

The terms “installed” and “supplied” are used interchangeable within this standard and both terms include the supply, installation and commissioning of the stated item.

These standards supersede all previous City of London Standards related to Environmental Service Facility Control and Automation.

The current version of this document at time of Tender Close will take precedence over all other documents and drawings that form part of the tender package.

It is the responsibility of the contractor to ensure that they obtain, review and fully understand all implications on the scope of set forth within the current version of these standards and all related documents released as of the day before the close of tender.

If their appears to be any contradiction between specific clauses within these standards it is the responsibility of the contractor to obtain clarification from the City or the contractor shall be responsible for any costs incurred as the result of subsequent clarification and resulting changes.

It is the responsibility of the contractor to request clarification before tender submission if it is not clear how the various component parts of the tender package interrelate.

(b) Process Philosophy

All process equipment shall be connected such that each and every device can be fully controlled remotely over the City of London Control Network.

Control systems for critical processes shall provide a level of redundancy such that the system adjusts for and maintains automatic control even following key equipment failures. It is the responsibility of the contractor to verify with the City whether a system is deemed critical.

Manual Control is not specifically discussed but is required for all equipment. Once a device is switched to local, control of the device shall be independent of (and unaffected by) the actions (or absence) of the controller.

Control systems shall be designed such that in the event of a controller failure process equipment can be operated manually.

Local electronic touch screen operator interface data panels shall be provided for all control panels with PLCs.

1.02 Programming

(a) General

This document describes the general framework to be followed for software development and the division of control and monitoring between PLC and SCADA.

It is recognized that under certain circumstances it may be necessary to deviate from the prescribed conventions and guidelines. In these cases, the integrator is to obtain approval for the deviation before deploying the deviation and shall, if requested by the City of London, examine the feasibility of other possible approaches that do not require the proposed deviation.

The purpose of this document is to ensure that a consistent approach to programming is followed on all projects. Consistency will enable:

1. Maximum re-use of program modules.
2. Reduced time to troubleshoot programs.
3. Greater flexibility to incorporate future modifications.
4. Improved confidence in automated control

1.03 Related Documents

(a) General

The following City of London documents contain additional requirements that also apply to all Automation and Control works.

1. City of London Automation & Control – Volume 1 Design Requirements
2. City of London Automation & Control – Volume 2 Standards (this document)
3. City of London Automation & Control – Volume 3 Programming Requirements
4. City of London SCADA Procedures Manual

All work shall exceed all requirements set forth by the latest addition of the following guidelines.

1. Canadian Electric Code (CEC)
2. Ontario Electrical Safety Code (OESC)

All work shall meet or exceed the recommendations set forth under the following standards.

1. Electronic Industries Association (EIA)

- ✓ EIA/TIA 606, Design Guidelines for Administration of Telecommunications Infrastructure in Commercial Buildings
- ✓ TIA SP-4195, Additional Transmission Performance Specifications for 4-Pair 100 Ohm Enhanced Category 5 Cabling
- ✓ ANSI/TIA/EIA-568-A, Addendum No. 5, UTP Performance classification and support data transmission rates to 100 Mb/s
- ✓ ANSI/TIA/EIA T568A, Color Code
- ✓ ANSI/TIA/EIA SP-4195 Addendum No. 5 to TIA/EIA-568-A Additional Transmission Performance Specifications for 4-Pair 100 Ohm Enhanced Category 5 Cabling (latest revision)
- ✓ EN50170-2-2:1996, Profibus Cabling Systems

2. National Electrical Manufacturers Association (NEMA/EEMAC)
   - ✓ PB 1, Panel Boards
   - ✓ 1CS-6, Enclosures for Industrial Controls and Systems
3. Factory Mutual (FM)
   - ✓ IS, Approval for Explosion Proof and Intrinsic Safety
4. Canadian Standards Association (CSA)
   - ✓ C6, Approval for explosion proof and intrinsic safety
   - ✓ T528-92, Design Guidelines for Administration of Telecommunications Infrastructure in Commercial Buildings
   - ✓ CAN/CSA-T529-M90, Commercial Building Standard for Telecommunications Pathways and Spaces
   - ✓ Device Registration Plate Requirements
5. International Society for Measurement and Control (Formerly ISA)
   - ✓ S5.1-1984, "Instrumentation Symbols and Identification."
   - ✓ RP60.6-1984 "Recommended Practice for Nameplates, Labels, and Tags for Control Centres"
   - ✓ S50.1, Electronic Industrial Process Instruments Analog Signal Compatibility
6. Underwriters Laboratories (UL)
   - ✓ UL 67, Panel Boards
   - ✓ UL 50, Cabinets and Boxes
   - ✓ UL 489, Moulded Case Circuit Breakers
   - ✓ UL 508, Standards for Industrial Control Equipment
   - ✓ UL 943, GFCI
   - ✓ UL 1449, Safety Transient Voltage Surge Suppressors
   - ✓ In the absence of other specific standards, the general guidelines set forth by the following organizations shall apply.

1. Canadian Electrical Manufacturers Association (CEMA)
2. International Society for Measurement and Control (ISA)
3. National Electrical Manufacturers Association (EEMAC)
4. National Fire Protection Association (NFPA)

5. Canadian Standards Association (CSA)
6. Institute of Electrical and Electronic Engineers (IEEE)
7. Electronic Industries Association (EIA)
8. National Fire Protection Association (NFPA)

PART 2 SOFTWARE DEVELOPMENT

2.01 Common

(a) General

This section describes the following:

1. Activities and sequence of events that shall be followed when developing control application software.
2. Review and testing procedures to be followed to ensure a quality product.
3. Work planning and tracking procedures used to ensure critical construction deadlines are met and the project remains within budget.

2.02 Application Development Process

(a) General

The contractor shall develop and obtain consensus on detailed process narratives before any programming begins.

SCADA and PLC Configuring shall be carried out in parallel on two separate but highly connected paths. For example, developing the SCADA is dependent on items such as PLC register assignment. The SCADA is developed using an object based system. All device templates and graphics have been pre-designed and are contained in the system platform database. As such all SCADA work will be carried out by City of London staff. Any new object templates or graphics required will be developed by City staff based on object attributes required by the new device. The following steps are suggested methodology that is to be followed unless the contractor submits an alternate plan and the City approves the use of the alternate plan.

(b) SCADA Configuration

1. Determine modifications, if any, required to the existing base SCADA application
   - ✓ Review with Operations
2. Repeat the following for each process screen
   - ✓ Develop a brief outline describing the screens purpose (how the screen relates to the control philosophy)
   - ✓ Define how screen will fit within the control application navigation map
   - ✓ Identify information to be displayed (equipment status, analog values, bar charts, analog gauges, trends, real time trends, animation, alarms, etc.)
   - ✓ Determine control to be provided
   - ✓ Define desirable hotlinks to Trends
   - ✓ Review with Operations
3. Generate process-specific database points
4. Application Predevelopment
   - ✓ Determine required objects for screen graphics

- ✓ Review City of London object library
- ✓ Develop any required additional objects
- ✓ Review with Operations
- ✓ Revise accordingly

5. Repeat the following steps for each screen
   - ✓ Develop Screens using City of London object library
   - ✓ Demonstrate using simulation system
   - ✓ Review with Operations
   - ✓ Incorporate Requested Modifications
   - ✓ Test & debug using simulation system
6. Field commissioning & tuning
   - ✓ Review with Operations
   - ✓ Incorporate Requested Modifications
   - ✓ Test & debug SCADA & PLC as integrated system

(c) PLC

1. Application Predevelopment
   - ✓ Determine required function blocks (control automation & device interface)
   - ✓ Review City of London program function blocks library
   - ✓ Develop any required additional program function blocks
   - ✓ Review with Operations
   - ✓ Incorporate requested modifications
2. Repeat the following steps for each PLC
   - ✓ Define required register assignments with variable names including complete descriptions
   - ✓ Define and program required input buffering and conditioning and output buffering
   - ✓ Define and program serial and Ethernet communication
   - ✓ Assign and configure device interface blocks to provide device drivers
   - ✓ Assign and configure control automation blocks to provide automatic control logic
   - ✓ Demonstrate using the simulation system
   - ✓ Review with Operations
   - ✓ Incorporate Requested Modifications
   - ✓ Test & debug using the simulation system
3. Field modifications & tuning
   - ✓ Review with Operations
   - ✓ Incorporate Requested Modifications
   - ✓ Test and debug SCADA & PLC as integrated system

2.03 Quality Assurance

(a) General

Application software quality is measured by how closely functions address plant operator requirements. For this reason, input from plant personnel is the most important factor in assuring a quality product. City input is to be solicited as follows.

1. Information provided in these standards.
2. Solicitation of input from plant operators during preparation of the process narratives and programming reviews.
3. Formal approval of the final process narratives before any programming begins.
4. Provide plant operators with an informal demonstration at the simulation-testing phase to get their feedback with the system and familiarize them with the control system revisions.
5. Have operations and maintenance staffs witness a formal field demonstration and obtain formal approval of the new system from the City of London.
6. All programs shall conform to IEC-1132 and IEC-848. In addition, the programs written for critical or hazardous applications shall conform to CAN/CSA-Q396.

2.04 Work Planning and Tracking

(a) General

A tracking table will be maintained for all PLCs and process areas impacted by work completed under the contract. This table will contain information that tracks PLC and SCADA applications development consistent with the application development process outlined previously. Revisions shall be tracked by incrementing the version number (Vx_x) and a detailed record outlining the changes made at each revision level shall be maintained.

2.05 Programing & Documentation - Identifiers

(a) Programming Tagnames

PLC Register and SCADA Tagname descriptors must:

1. Be kept as simple and as readily understandable as possible;
2. Be kept consistent throughout the program;

- Reference specific pieces of equipment or instrumentation by using London Standard device identifiers.

(b) PLC Nickname

PLC program nicknames consist the device identifier followed by an action modifier.

3. Device identifier - This portion of the tagname identifies the process and equipment. If the PLC controls more than one section it is also necessary to preface the tagname with section.
4. Action Modifier - A two or three character designation of the related action or function. Whenever possible, use the identification in the field cabling action modifier list. If the applicable modifier cannot be located in the table, use two-character identifiers based on the ISA standard naming conventions for process and electrical design drawings.

(c) SCADA Tagnames

SCADA tagnames consist the device identifier followed by an action modifier.

5. Device identifier: This portion of the tagname identifies the facility, section, process and equipment.
6. Action Modifier - A two or three character designation of the related action or function. Whenever possible, use the identification in the field cabling action modifier list. If the applicable modifier cannot be located in the table, use two-character identifiers based on the ISA standard naming conventions for process and electrical design drawings.

Whenever representing a datum from the PLC, use the same identification as in the PLC with the addition of the facility and section information. Where the information is field generated, the tagname will be consistent with that used for wire identification.

(d) Drawings

Drawing numbers are to be prefixed with the location, section, process and building descriptor previously set forth. In cases where more than one process or buildings are indicated on the same construction drawing, this element may be deleted.

This is to be followed by standard construction drawing indexing as identified within the City of London Drafting Standard.

2.06 Programing & Documentation - Colour Coding

(a) General

Operator displays for water and wastewater facilities, at all levels, shall conform to the following colour convention:

Screen Background

DESCRIPTION	COLOUR	RGB
Normal Operation	Light Grey	240, 240, 240
Device on Screen in Alarm	Yellow	255, 255, 0

* Flashing is between current status colour and grey at normal flashing frequency (84 to 168 flashes per minute).

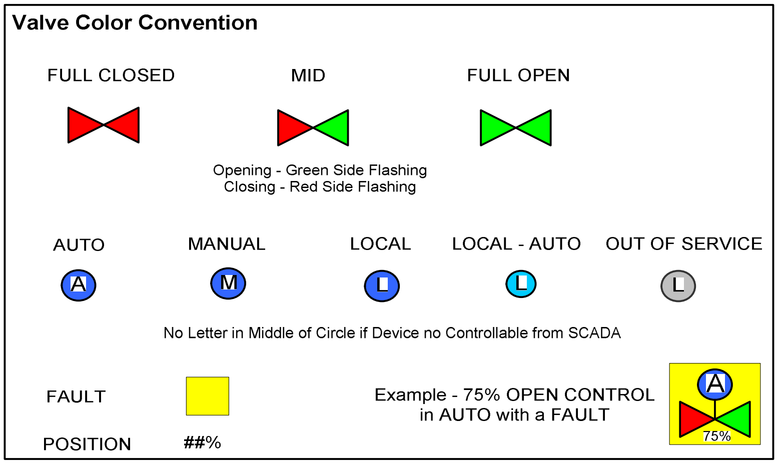
Process Colour

DESCRIPTION	COLOUR (RGB)
Air – Circulating	Green (0,230,0)
Air – Compressed	Dark Green (0,100,0)
Chemical – Alum, Ferric Chloride, Ferrous Chloride, Fluoride	Orange (255,100,0)
Chemical – Chlorine (including hypo-chlorite)	Yellow (250,240,0)
Chemical – Lime	White (255,255,255)
Chemical – Polyelectrolytes	Silver (210,210,220)
Chemical – Potassium Permanganate	Violet (100,50,150)
Fuel – Digester Gas or Fuel Oil	Orange (255,100,0)
Fuel – Natural Gas, Propane	Red (255,0,0)
Miscellaneous – Grit, Screenings & Drainage	Black (0,0,0)
Sewage – Activated Sludge (RAS & WAS)	Light Brown (190,160,90)
Sewage – Chlorinated / UV Treated Effluent	Light Blue (0,255,255)
Sewage – Primary & Secondary Effluent	Light Grey (170,170,170)
Sewage – Raw	Tan (205,205,120)
Sewage – Sludge (Other)	Dark Brown (100,50,0)
Water – Non-potable, Plant, Seal	Light Blue (0,255,255)
Water – Potable Hot Water	White (255,255,255)
Water – Potable	Dark Blue (0,0,190)

Digital Equipment/Device Status

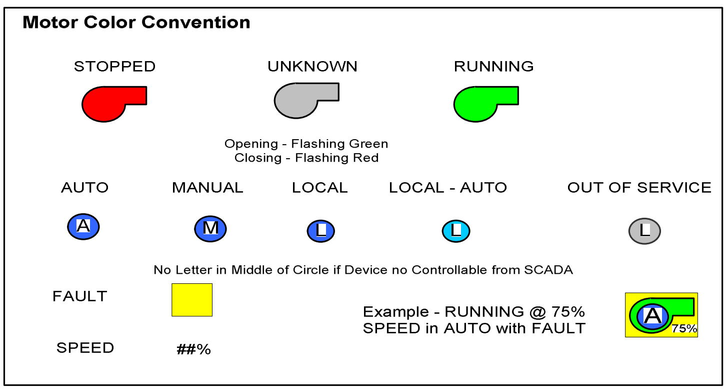
VALVES & SIMILAR DEVICES	COLOUR (RGB)
Open	Green (0,255,0)
Opening (In transition)	Red & Green – Green Side Slow Flash
Partially Open (Intermediate position)	Red & Green
Closed	Red (255,0,0)
Closing (In transition)	Red & Green – Red Side Slow Flash
Fault	Yellow (255,255,0)

Flashing is between current status colour and grey at a slow rate (30 flashes per minute). Fast flashing (90 flashes per minute) is reserved for alarm unacknowledged.



PUMPS & SIMILAR DEVICES	**COLOUR**
On, Active	Green (0,255,0)
Starting, Activating (In transition)	Green Slow Flash
Off, Inactive	Red (255,0,0)
Closing, Disengaging (In transition)	Red Slow Flash
Fault	Yellow (255,255,0)
Interlock Bypassed / Local Control	Orange (255,100,0)

Flashing is between current status colour and grey at a slow rate (30 flashes per minute).



Analog Values

DESCRIPTION	**COLOUR**
Normal range	White on Black
Advisory range	Cyan on Black
Alarm range	Yellow on Black
Off scan or communications failed (last value)	Purple on Black

Control Modes

DESCRIPTION	COLOUR
Local	Black
Local Auto	Cyan
Out of Service	Light Grey
Auto	Blue
Manual	White

Identification Labels

DESCRIPTION	COLOUR
Screen Titles, Equipment, etc on Light Background	Black
Screen Titles, Equipment, etc on Dark Background	White

Miscellaneous

DESCRIPTION	COLOUR	RGB
Equipment Outlines (tank, etc.)	Dark Grey	132, 132, 132
Building Outlines, etc.	Dark Grey	
Active Buttons	Black Text, Grey Background	
Inactive Buttons	Dark Grey Text, Grey Background	

PART 3 ALARMS

3.01 Common

(a) General

This section contains a guideline on what alarms need to be brought into the control system. Specific examples are defined here, but not all alarms are listed. The requirements of each facility will require additional design. The purpose of this section is to establish standards that will provide a framework for information to be alarmed.

Uniformly applied principles of alarming will help operators respond appropriately to abnormal situations.

Operators shall be able to view all alarm conditions throughout the system from any OI. At shift change, operations staff will review the alarm summary display and deal all displayed alarms before starting on other duties. Priority alarms will be addressed when paged as operators will normally be performing other tasks and will not be monitoring an OI. As such, all conditions that require operator response before next change of shift shall be paged.

3.02 Priority

(a) General

Priority shall be based upon how quickly operator attention is required in order to address the problems.

1. Priority 1 alarms require immediate operator attention.
2. Priority 2 alarms require operator attention as soon as convenient (typically 30 to 90 minutes).
3. Priority 3 alarms can be addressed at next shift change.
4. Priority 4 alarms provide operational status information and do not require operator intervention.
5. Events do not require operator attention.

3.03 Priority Assignment Guidelines

(a) General

Alarms shall be assigned priority consistently across all plants in order to more safely cross train operators on different processes in order to compare performance.

For new alarm points, software developers shall assign preliminary priorities based upon the examples in the following table. Before commissioning the priorities shall be reviewed with operations management and revised accordingly.

Alarm	Priority
Critical water quality conditions	1
Pump fail and its standby unit could not be started up	1
Pump fail and its standby unit was started successfully	3
Chlorine leak	1
Chemical spill (ferric chloride, sodium hypo-chlorite)	1
Combustible gas (methane, natural gas) concentration high	1
Toxic gas (carbon dioxide, hydrogen sulphide) concentration high	1
Flood	1
High wet well level	1
Process controller failure	1
Historical logging failure	2
Operator interface failure	3
Local Alarms Disabled	3
Failure of auxiliary systems (instrument air, lubrication system, heating, cooling, ventilation system, backup instrument power)	2
Instrument failure	2
Dissolved oxygen concentration low	2
Device switched out of Auto Mode	4

For additional information on SCADA Alarm Configuration see City of London standard for PLC & SCADA Programming.

3.04 Safety Alarms

(a) General

Safety alarms are defined as those involving personal safety of the operator (fire, gas leak, chorine leak, etc.) or those involving potential process damage (flooding, etc.).

1. All safety equipment such as chlorine gas detectors, fire detectors, etc. shall provide local alarm annunciation in addition to communicating with the control system. Annunciation shall take the form of a flashing strobe and 120db alarm horn.
2. To ensure communication problems do not reduce the level of protection provided, monitoring loops shall either be 3-wire form C circuits with one state always energized or in the case of serial or fieldbus communications the monitoring device shall be regularly polled to confirm communication.
3. Local test switches shall be provided which tests lights, horns and circuits for readiness to operate.

4. The only method to acknowledge safety alarms shall be by manually pressing a local alarm reset located in the zone monitored by the safety alarm.

3.05 Alarm Activation

(a) General

All alarms shall latch in alarm state until acknowledged with the exceptions of alarms which are driven solely by self curing process changes such as under voltage (power failure), seal water low pressure or low suction pressure.

Alarms shall be suppression during start-up or shutdown of a device or a process where those alarm conditions are irrelevant during these periods.

Alarms shall be reviewed during the control strategy design stage on a case-by-case basis to confirm appropriate behaviour.

3.06 Alarm Monitoring Concept

(a) General

The alarm monitoring practice is to bring into the SCADA system sufficient alarm details as needed for remote diagnosis of problems. The alarm and related information shall enable appropriate responses to be taken. The number of alarms from a particular device or facility shall be reviewed on a case-by-case basis with the City of London.

Abnormal status of all auxiliary systems that are essential to the functioning of the control system and/or process equipment (e.g. instrument air supply pressure) shall be alarmed.

Additional details shall be included in Priority 1 alarm descriptions in order to allow appropriate action to be quickly taken. For example, a general alarm is not acceptable for a combustible gas sensor. In this example, individual alarms shall be provided for combustible gas detected, high concentration combustible gas detected, sensor fault detected, alarm test triggered and detector offline for maintenance. For the alarm conditions, the alarm message must include details such as the actual combustible gas concentration.

3.07 Paging Requirements

(a) General

The paging shall provide full alphanumeric pages such that operators are provided with the full text message for each alarm condition.

Pager will be assigned to specific operational area or function to support automatic dialling on alarm conditions. A specific staff member will be assigned the pager for a given shift. In this way, the responsibility for responding to alarms is easily understood. If the individual has a pager and receives a page they are responsible for responding.

If a page is not acknowledged within a set time, the paging system will page the shift supervisor.

The paging system shall support access by phone both for acknowledgement and review of alarm conditions. Voice messages provided shall include full descriptions of all menu choices and alarm conditions.

PART 4 CONTROL SOFTWARE DESIGN

4.01 Common

(a) General

The overall system is to be designed in a modular fashion in order to facilitate easy integration and removal of pumping stations as new pumping station come on line and others are decommissioned.

This section defines the specific roles played by the PLC and the SCADA in providing an integrated control and monitoring solution. This includes describing how these two components shall interact.

In addition to programming IO that is currently in place, provisions will be made for future expansion of the system. As part of this philosophy, "spare" field IO will be configured from strategic locations to provide for ease of installation and commissioning of equipment pilot testing.

4.02 Data Communications

(a) General

The following bullets outline how communication between PLC and SCADA is to occur.

1. Each PLC & SCADA node will have individual unique network addresses on each network segment upon which they reside. IP addresses will be hard coded for all SCADA & PLC nodes.
2. In order to ensure the system remains functional if remote name service providers are inaccessible, SCADA nodes will be provided with local WINS lookup tables.
3. PLC's that are deployed in a hot standby configuration shall have consecutive node addresses.
4. All PLCs & SCADA nodes shall have internal clocks synchronized periodically to a master clock. Synchronization shall provide time and date stamping accuracy to within one second of the master clock for all nodes.
5. All analog values shall be converted into floating point values in the PLC
6. Read & Write registers are to be unique (e.g. SCADA writes to %Rx to set value, but reads value back from %Rz to display value).
7. Discrete control actions shall use a single bit (e.g. setting %Mx starts device, resetting %Mx stops the device).
8. Control automation and monitoring shall continue without disruption in the event of communication failures. Where control functions rely on information affected by communications failure, a safe mode control shall be provided.
9. The virtual network topology shall consist of three layers (i.e. IP segments) as follows.
   - ✓ Level 1 – Real-time (PLC to PLC & PLC to SCADA)
   - ✓ Level 2 – SCADA (SCADA to SCADA, SCADA to SCADA WEB)
   - ✓ Level 3 – Admin (SCADA WEB to World, Admin Apps – e.g. email, JDE, etc.)

10. The physical network topology shall consist of two isolated physical networks with provisions for future implementation of quality of service isolation for Layer 1.
    - ✓ Layer 1 – Real-time
    - ✓ Layer 2 – Sewage SCADA & Admin
11. In order to ensure consistency throughout the system Tag Parameter Matrix Tag/Register parameters are to be defined at the lowest level possible and are to be consistent throughout the system. For example, the description used in the PLC for the register is to match the description for the corresponding tag in the SCADA.

4.03 PLC Functions

(a) General

In general, the PLC is to perform the following functions.

1. Provide self-sustaining control automation (i.e. run independent of SCADA & other PLCs)
2. Collect data from all field devices not directly connected to the IP network
3. Provide all automated control functions
4. Detect critical alarm conditions and provide annunciation (Facility Alarm Horn)
5. Sequence operation of equipment based on duty cycle, failure, operator request, time of day, etc.
6. Provide process optimization automation (e.g. D.O. based Blower Control)
7. Monitor breakers (where provision for mechanical lockouts are required at the field device)
8. Monitor all field device interlocks (both hard wired and programmed)

Functionality not specifically required within the PLC for control purposes will be performed by the SCADA. For example, analog alarm management (HIHI, HI, LO, LOLO alarm determination) is to be managed by the SCADA. The objective is to ensure that PLC programs are kept as simple as possible.

4.04 SCADA Functions

(a) General

In general, the SCADA is to perform the following functions.

1. Provide operators with a interface to monitor and control the various process systems addressed
2. Provide real time supervisory monitoring and operational information management
3. Provide comprehensive alarm management and generate various alarms based upon various information monitored
4. Manage all historical alarms, trends and detailed historical operational data
5. Generate SQL tables of historical statistical summary information (daily flow totals, chemical consumption, etc.)

6. Calculate and generate SQL tables of maintenance related information such as equipment run-times, and start/stop frequency counts for equipment with intermittent duty cycles such as: motors, generators, and pumps.
7. Perform all data manipulation such as summation and subtraction that is used for display or historical data but not used for control purposes within the PLC.

PART 5 PLC PROGRAMMING

5.01 Common

(a) General

This document is a guideline to the program style, structure and internal documentation of PLC programs.

It is recognized that under certain circumstances it may be necessary to deviate from the prescribed conventions and guidelines. In these cases, the integrator is to obtain approval for the deviation before deploying the deviation and shall, if requested by the City of London, examine the feasibility of other possible approaches that do not require the proposed deviation.

This standard is one in a series of interrelated standards that must be viewed together in order to ensure a complete understanding of the scope of work to be completed.

(b) Application Folder Contents

Panel drawings, I&C drawings, control philosophies, and related documents shall be incorporated as PDF objects in the application folder as part of internal program documentation.

5.02 Program Structure

(a) General

The following details describe the structure to be followed for PLC programs.

The following program block structure is to be followed. The block names for the specific blocks listed shall be as stated within the parenthesis.

1. First Scan and Start-up (STARTUP)
    - This block performs all initial housekeeping and initialization of all addresses. The programming within this block is run only once upon the PLC transitioning from Off to Run.
2. Simulation (SIM)
    - This block simulates field I/O as required to allow the program to be tested and debugged before connection to actual field devices. This block shall be interlocked with the I/O disabled contact such that the simulation code will only function when I/O is disabled. Under normal operation, this blocks' rung is disabled by the ALW_OFF contact.
3. Communication (DATACOM)
    - This block manages communication PLC to Remote IO, PLC to PLC and PLC to SCADA. This includes monitoring communication status for each communication link.
    - For all new programs, the communication from PLC to SCADA will not utilize DATACOM block; the SCADA will read bit, integer and floating point memory

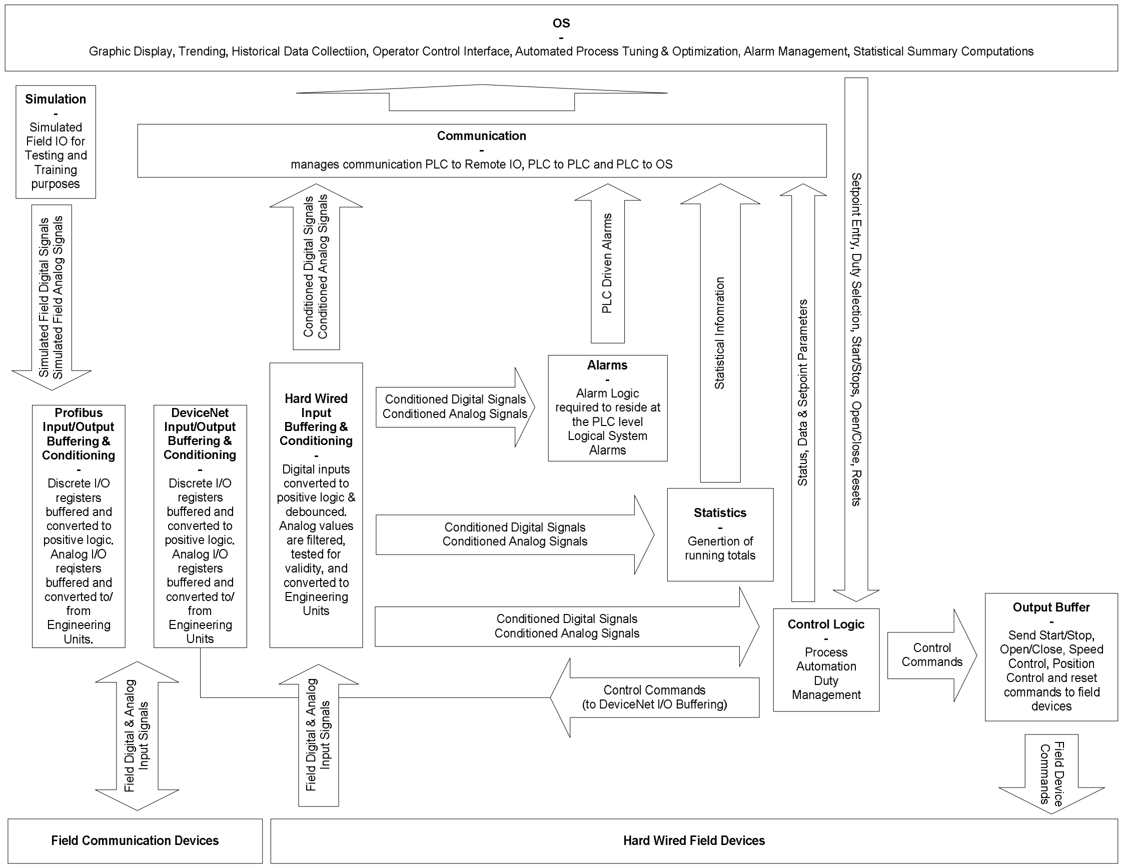
addresses directly from DeviceNet, Profibus, Input Buffer, Driver and Process Automation Block Subroutines.

4. Input Buffering and Conditioning – Conventional Signals (IN_BUF)
   - This block moves a data image of all real world inputs into internal registers, buffering and conditioning the real world I/O for direct use in the PLC program logic. This includes conventional hard-wired signals only.
   - For discrete inputs, as part of buffering to internal registers negative logic signals will be inverted such that all logic development can be completed as positive logic.
   - If required, the timers are used to condition hard-wired discrete inputs, addressing noise problems, or holding transient alarms for an adequate duration (e.g. door limit switches) for the event to be captured by the SCADA.
   - For discrete inputs the buffering and conditioning will be performed in a single rung.
   - For analog inputs, field values are to be converted to floating point values.
   - For analog values, values will be checked to determine validity. Each analog value shall have an associated discrete status bit which will be set if the information is invalid. Analog values will also be dampened where signal noise may be a problem.
5. Input/Output Data Management – Field Communication Signals (DEV_NET & PROFIBS)
   - For the DeviceNet and Profibus field communication devices, each specific block manages buffering and scaling of the input and output data registers.
   - Field communication input and output data registers are assigned (buffered) in the “Hardware Configuration”. The preferred device hardware configuration selection is one that contains even number of bytes, so buffered input/output data registers are assigned to 16-bit buffered registers.
   - The common communication start-up and enabling registers / bits are set at the beginning of the each block, where required.
   - The input and output data management for each device is to be grouped into successive rungs, commented as a minimum at the beginning of each subgroup (e.g. discrete inputs, analog inputs, discrete outputs, and analog outputs). For analog signal, the comments also need to have the information on the scaling factors (e.g. range of scaling and scaled registers).
   - Discrete data inputs are moved from buffered input data registers into internal bit-memory, converting negative logic signals into positive where required.
   - Discrete data outputs are moved from internal bit-memory into 16-bit buffered output data registers.
   - Analog data inputs are validated, aligned, scaled and moved from buffered input data registers to corresponding internal registers.
   - Analog data outputs are scaled and aligned from corresponding internal registers to buffered output data registers.
6. Alarm Handling (ALARM)

- This block manages PLC derived alarms. These alarms are limited to those alarms that are used within the control logic, alarms that trigger local alarm horns, and the local alarm test system (local alarm test & acknowledge buttons).

7. Statistical Processes (AI_STAT or STAT)
   - The logic within this subroutine generates running totals such as process variable totals, number of start/stops, and other running totals.
8. Control Logic
   - System and subsystem blocks are to be named in conformance with the City of London's equipment element naming conventions.
   - Program function blocks are to be arranged in a hierarchal structure with control for each subsystem programmed as a separate block assigned as a sub-block to the associated system block. All system blocks are to reside as sub-blocks to the Control Logic Block. The deviation can be accepted for PLCs that control single process subsystem, such as a PLC for a pumping station or part of the plant.
   - The control logic will consist of device algorithms - drivers, and process automation algorithms.
     - Device drivers (postscript DRV) contain: operational and mode permissive, auto/manual selection, start/stop logic, standard alarms and lockout including resets, multi-digital mode status and elapse time meter.
     - The standard process automation algorithms contain one or all of the required common logic for duty selection (ps DTY), duty start/stop request and sequencing (ps RQS and SEQ), or duty speed management (ps PRM and STOP).
   - All control logic associated with a given subsystem shall be programmed within the respective subsystem block.
   - Logic common to all subsystem blocks shall be programmed in the associated system block NOT within one of the subsystem blocks.
   - Each logical sequence will be subdivided into a well-defined series of simple steps. In order to monitor transitions between steps, a unique integer register shall be used as a pointer for each such sequence to ease with determining the currently active program step.
9. Output Buffer – Conventional Hard-wired Signals (OUT_BUF)
   - This block moves a data image of all corresponding internal registers to real world outputs. This includes conventional hard-wired signals only.
   - For discrete inputs, as part of moving the outputs from internal registers, outputs to devices which function based on negative logic will be inverted.
   - For analog inputs, internal values are to be converted from floating point engineering units to integer raw values.

The following diagram provides further clarification of PLC program data flow.

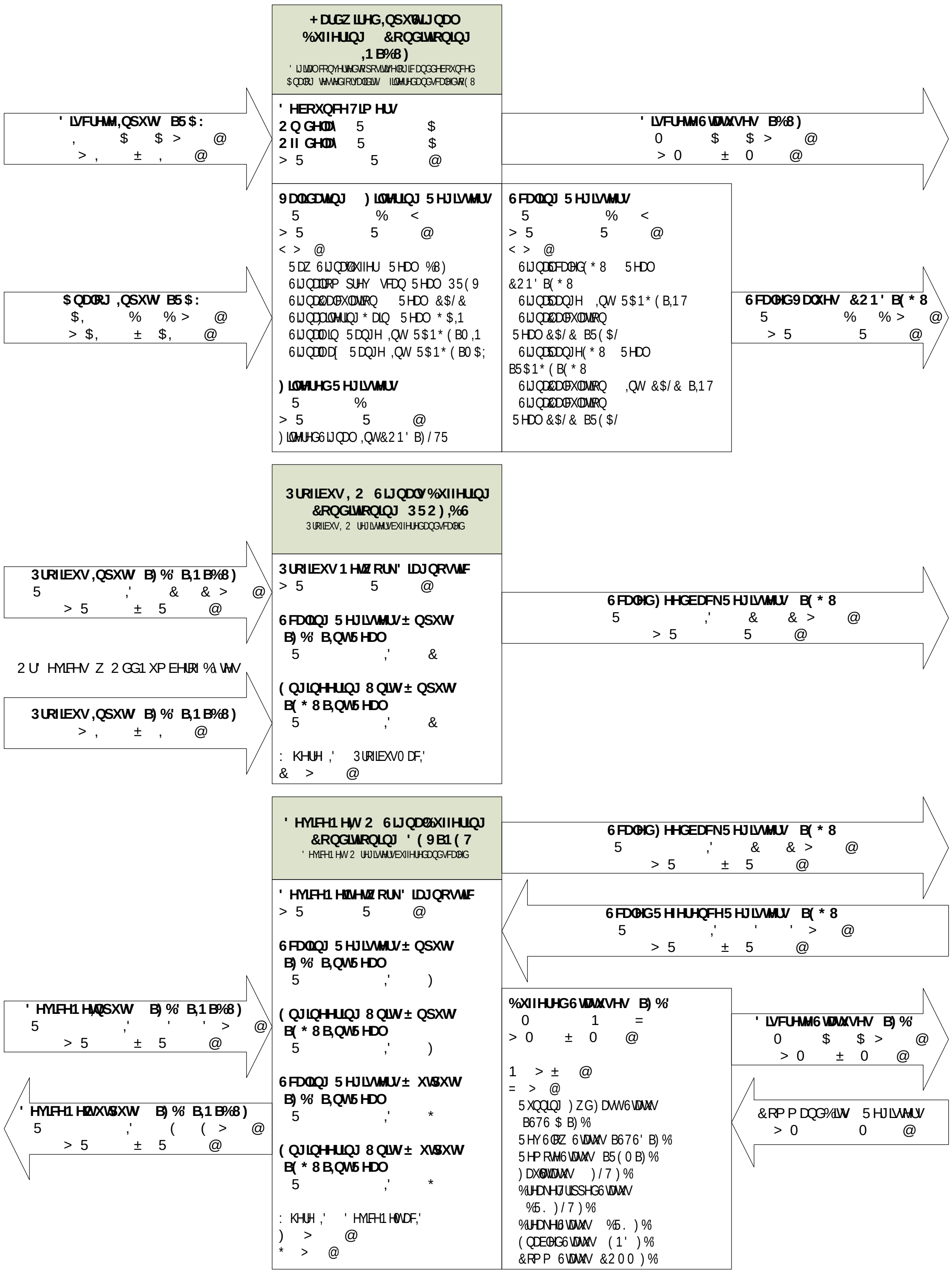

OS
-
Graphic Display, Trending, Historical Data Collectiion, Operator Control Interface, Automated Process Tuning & Optimization, Alarm Management, Statistical Summary Computations
Simulation
-
Simulated Field IO for Testing and Training purposes
Communication
-
manages communication PLC to Remote IO, PLC to PLC and PLC to OS
Simulated Field Digital Signals
Simulated Field Analog Signals
Conditioned Digital Signals
Conditioned Analog Signals
PLC Driven Alarms
Statistical Infomration
Status, Data & Setpoint Parameters
Setpoint Entry, Duty Selection, Start/Stops, Open/Close, Resets
Alarms
-
Alarm Logic required to reside at the PLC level Logical System Alarms
Profibus Input/Output Buffering & Conditioning
-
Discrete I/O registers buffered and converted to positive logic. Analog I/O registers buffered and converted to/ from Engineering Units.
DeviceNet Input/Output Buffering & Conditioning
-
Discrete I/O registers buffered and converted to positive logic. Analog I/O registers buffered and converted to/ from Engineering Units
Hard Wired Input Buffering & Conditioning
-
Digital inputs converted to positive logic & debounced. Analog values are filtered, tested for validity, and converted to Engineering Units
Conditioned Digital Signals
Conditioned Analog Signals
Statistics
-
Genertion of running totals
Conditioned Digital Signals
Conditioned Analog Signals
Control Logic
-
Process Automation Duty Management
Control Commands
Output Buffer
-
Send Start/Stop, Open/Close, Speed Control, Position Control and reset commands to field devices
Control Commands
(to DeviceNet I/O Buffering)
Field Digital & Analog Input Signals
Field Digital & Analog Input Signals
Field Device Commands
Field Communication Devices
Hard Wired Field Devices

5.03 PLC Memory Organization

Programs shall comply with the following memory organization conventions and guidelines.

1. PLC memory will be organized into segments.
2. Each segment will contain adequate memory for future expansion.
3. Within each section, the memory will be organized into logical blocks with adequate room for future expansion. The memory / register allocation shall conform to the City of London's standard Memory Allocation Table. *This information is maintained in a spreadsheet which is available upon request*.
4. When configuring PLC Memory registers, the following guidelines shall be followed.
   - Within the programming software, the register name and description shall be in accordance with the City of London naming conventions.
   - In addition, the register length parameter shall be adjusted as required in order to ensure that register sequences associated with timers, PID blocks etc. are clearly defined.
   - Register assignment shall be organized in the same hierarchy as used for program structure. As such, blocks of registers shall be assigned to each system to be controlled. The block assigned will include adequate spares to allow for program modification without requiring additional registers to be assigned.

The following diagram expands the PLC program data flow with standard memory structure allocation.



	3URFHVV $XWRPDWLRQ 6XEURXWLQHV 3,' V 'XW 0DQDJHPHQW $XWRPDWLRQ &RQWURO	&RQWURO/RJLF 'ULYHU 6XEURXWLQHV &RQWURO/RJLF 'ULYHUV SURFHVV DXWRPDWLRQ
'LVFUHWH 6WDWXVHV B%8) 0 $ $ > @ > 0 ± 0 @ 6FDOHG 9DOXHV &21'B(*8 5 % % > @ > 5 5 @ 6FDOHG) HHGEDFN 5HJLVWHUV B(*8 5 ,' & & > @ > 5 5 @ 6FDOHG) HHGEDFN 5HJLVWHUV B(*8 5 ,' & & > @ > 5 ± 5 @ 6FDOHG 5HIHUHQFH 5HJLVWHUV B(*8 5 ,' ' ' > @ > 5 ± 5 @ 'LVFUHWH 6WDWXVHV B)%' 0 $ $ > @ > 0 ± 0 @ &RPPDQG %LWV 5HJLVWHUV > 0 0 @	$XWRPDWLF 6HTXHQFH 6WDWXVHV 0 N N > @ > 0 ± 0 @ 3,' 5RXWLQH 5HJLVWHUV 5 P P > @ > 5 ± 5 @ $XWRPDWLF 6HTXHQFH 5HJLVWHUV 5 Q Q > @ > 5 ± 5 @	'ULYHU 1 > @ &RQWURO %LWV IURP 6&$'$ 2,7 * 1 8 > * * @ 6WDWXV %LWV 0 1 9 > 0 0 @ 6LJQDO EHRXQFH 7LPHUV 5 1 : 8 > @ 0DQXDO &RPPDQG +0, B0$1B+0, $XWR &RPPDQG +0, B$87B+0, 6WDUW) RUZDUG 6ORZ 2SHQ &RPPDQG +0 B67$B+0, B23B+0, 6WRS &ORVH &RPPDQG +0, B63B+0, B&/B+0, 5HYHUVH) DVW 6WRS &RPPDQG +0, B67'B+0, B63B+0, VWRS IRU YDOYHV RQO\ @ $ODUP 5HVHW 0, B$567B+0, /RFNRXW 5HVHW 0, B/.567B+0, 9 > @ 2SHUDWLRQDO 3HUPLVVLYH B'59B2350 0RGH 3HUPLVVLYH B0350 0RWRU 0HPRU\ B'59B00(0 &RPS B$XWR 0RGH B'59B$87 %XPSOHVV 7UDQVIHU WR 6WDUW) RUZDUG 6ORZ 2SHQ B'59B67$75) B'59B2375) %XPSOHVV 7UDQVIHU WR 5HYHUVH) DVW &ORVH B'59B67'75) B'59B&/75) 6WDUW) RUZDUG 6ORZ 2SHQ 5HTXHVWHG B67$ B'59B&0' B23 B'59B&0' 6WRS &ORVH 5HTXHVWHG B63 B'59B&0' B&/ B'59B&0' 5HYHUVH) DVW 5HTXHVWHG B67' B'59B&0') DLOHG WR 6WDUW) RUZDUG 6ORZ 2SHQ B'59B67) /7 B'59B23) /7) DLOHG WR 6WRS 2SHQ B'59B63) /7 B'59B&/) /7) DLOHG WR 5HYHUVH) DVW B'59B67') /7 8QFRPPDQGHG 6WDUW) RUZDUG 6ORZ 2SHQ B'59B8&67$ B'59B8&23 8QFRPPDQGHG 6WRS &ORVH B'59B8&63 B'59B8&&/ 8QFRPPDQGHG 5HYHUVH 'XW\ %DFNXS 6WDUW) RUZDUG 6ORZ 2SHQ 5HTXHVWHG B'7<67$ B'59B&0' B'7<23 B'59B&0' /RFNRXW B'59B/. *HQHUDO $ODUP B'59B*$ $ODUP 5HVHW B'59B*$567 /RFNRXW 5HVHW B'59B/.567 9 > @ %XPSOHVV 7UDQVIHU WR 6WDUW) RUZDUG 6ORZ 2SHQ 2II 'HOD\ 7LPHU ,QW %XPSOHVV 7UDQVIHU WR 5HYHUVH &ORVH 2II 'HOD\ 7LPHU ,QW) DLO WR 6WDUW) RUZDUG 6ORZ 2SHQ 2Q 'HOD\ 7LPHU ,QW) DLO WR 6WRS &ORVH 2Q 'HOD\ 7LPHU ,QW) DLO WR 5HYHUVH) DVW 2Q 'HOD\ 7LPHU ,QW 8QFRPPDQGHG 6WDUW) RUZDUG 6ORZ 2SHQ 2Q 'HOD\ 7LPHU ,QW 8QFRPPDQGHG 6WRS &ORVH 2Q 'HOD\ 7LPHU ,QW 8QFRPPDQGHG 5HYHUVH) DVW 2Q 'HOD\ 7LPHU ,QW 'XW\ %DFNXS 6WDUW 2Q 'HOD\ 7LPHU ,QW (ODSVH 7LPH 0HWHU (70 5HDO

5.04 Field I/O Configuration

(a) Conventional Analog I/O

1. Field Equipment is to be calibrated for 4-20mA
2. PLC I/O blocks are to be configured as 0-20mA
3. PLC / SCADA Logic shall recognize <4mA as BAD Data / Device Offline and adjust functions accordingly.

(b) Field Communication I/O

1. In situations where information is either not available, or the device indicates that the information may be questionable, the 0 value shall be transferred to the associated register; and PLC / SCADA Logic shall recognize the data provided as indicating BAD Data / Device Offline and adjust functions accordingly.
2. The DeviceNet I/O data assemblies shall be programmed using standard DeviceNet programming tools, assigning even number of bytes to each node I/O assembly. Where node can not be assigned with even number of bytes in a standard form, additional hardware or software shall be provided to achieve the requirement.
3. The Profibus I/O data assemblies shall be programmed using standard Profibus programming tools, assigning even number of bytes to each node I/O assembly. Where node can not be assigned with even number of bytes in a standard form, the data buffering will be performed using byte-aligned %I discrete inputs memory allocations.

5.05 Programming Techniques

Programs shall comply with the following programming conventions and guidelines.

1. Program names shall be formatted as PCOX-RPU02 2008-07-14, corresponding to Oxford Pollution Control Plant RPU #2, revision 2008-07-14.
2. PLCs are to be programming exclusively using ladder logic.
3. The first program block shall only be run on first scan.
   - Set points shall be stored as retentive register values to allow these values to be adjusted without modification to the actual program.
   - This block will copy all default values to associated control registers.
   - At pumping stations, the programming software shall be used to manipulate the default register values.
   - At plants, certain default values shall be configured only by the programming software, however other values shall be adjustable from the SCADA computers.
4. All analog I/O shall be converted to floating point as part of the preconditioning process (i.e. performed within the data conditioning block).
5. Alternatively, the following I/O shall be allowed to be used as integer values scaled to a modified engineering units:
   - VFD speed: scaled to 100Hz, range 0 – 6000 [100Hz] representing 0.00 – 60.00 Hz;
   - Liquid or material level: scaled to [mm], e.g. range 0 – 5600 [mm] representing 0.000 – 5.600 [m].
6. Following modified engineering units will be used for an instantaneous flow:

- Flow for individual water or wastewater pumps (plant or pumping station), equipment feed, or chemical feed: [l/s];
- Return, waste, effluent, total section/plant inflow/outflow: [m^3/day];
- Aeration flow: [m^3/hr].

7. Device interface and control automation logic shall use exclusively discrete coils & floating point registers.
8. Where more than one line of logic is required in order to perform a required function continuation contacts shall be used. Continuation logic, which uses the continuation contact, will immediately follow the line ending with the associated continuation coil.
9. Coils and registers set by the SCADA can be directly used within program logic. For all new programs, the coils and registers monitored by the SCADA for data transfer confirmation shall be red directly from the actual control logic without use of DATACOM. The existing programs, however, may contain the logic in the DATACOM subroutine where coils and registers monitored by the SCADA for data transfer confirmation shall be buffered from the actual control logic and other subroutines.
10. Where it is necessary to maintain a coil, control logic will use set & reset coils. All lines of logic associated with the control of a common coil (i.e. set/reset coils) will immediately follow each other logic within the program and shall always reside within the same program block. Self-sealing control logic shall not be used.
11. In general, outputs are to be used referenced only once within the program. The only exceptions are those outputs controlled by set/reset logic which function in pairs, and values which are initiated in the "run first" program block. Even under these unique circumstances, references within the program are not to exceed two (2).
12. As a precursor to each rung, a comment shall be provided which outlines in clear English the function performed by the rung (or grouping of rungs in the case of set/reset rungs or continuation rungs).
13. Every logical process shall be programmed as a separate program block. As a precursor to each program block, a detailed comment shall be provided which describes in detail the control philosophy achieved by the programming within the block.
14. Output rung enabling conditions shall be grouped at the beginning of each rung followed by conditions that inhibit the output at the end.
15. "Rack Running" interlocks are to be provided where an output rung is dependent on inputs and/or outputs from another rack or controller.
16. All programming is to be performed as positive logic (i.e. power flow indicates action)

17. Where built in control functions are provided as part of the programming language, such as PID loop control blocks, they shall be used in preference to custom programmed algorithms.
18. The following techniques, functions and data types are not to be used within the program.
    - Logic jumps
    - Temporary coils
    - Indirect addressing
    - Latching logic (as apposed to set/reset coils)
    - Momentary contacts
    - Master control relay
    - Equal operator in conjunction with floating point values
    - Bit masks
    - %T registers

19. Device status shall provide tri-state information to SCADA (Opened/In Transit/Closed) where analog value not provided.

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5.06 Program Tag Naming Conventions

	Field Wire Tag	INPUT **BUF**FER PROGRAM BLOCK Action for DI: Reverse Contact Action Action for AI: Test Validity (Limits)		Analog Type data are mapped to %R (BUF) and then Scaled (EGU) Discrete Type data are mapped to %I (BUF) and then to %M (STS)		INPUT **COND**ITIONING PROGRAM BLOCK Action for DI: Debounce Contact Action for AI: Filter and Scale	
EQUIPMENT TAG EXAMPLE:		Input Signal	Buffered Signal				
PSMD-B01-RSP1 (Pump)							
RUN CONTACT	PSMD-B01-RSP1-**RN**	B01-RSP1-RN**-RAW**	RSP1-RN**-BUF**			RSP1-RN**-COND-STS**	
OVERLOAD CONTACT	PSMD-B01-RSP1-**OL**	B01-RSP1-OL**-RAW**	RSP1-OL**-BUF**			RSP1-OL**-COND-STS**	
GENERAL ALARM CONTACT	PSMD-B01-RSP1-**GA**	B01-RSP1-GA**-RAW**	RSP1-GA**-BUF**			RSP1-GA**-COND-STS**	
FORWARD RUN CONTACT	PSMD-B01-RSP1-**FWD**	B01-RSP1-FWD**-RAW**	RSP1-FWD**-BUF**			RSP1-FWD**-COND-STS**	
REVERSE RUN CONTACT	PSMD-B01-RSP1-**REV**	B01-RSP1-REV**-RAW**	RSP1-REV**-BUF**			RSP1-REV**-COND-STS**	
FAILED CONTACT	PSMD-B01-RSP1-**FAL**	B01-RSP1-FAL**-RAW**	RSP1-FAL**-BUF**			RSP1-FAL**-COND-STS**	
FAULT CONTACT	PSMD-B01-RSP1-**FLT**	B01-RSP1-FLT**-RAW**	RSP1-FLT**-BUF**			RSP1-FLT**-COND-STS**	
REMOTE CONTROL MODE	PSMD-B01-RSP1-**REM**	B01-RSP1-REM**-RAW**	RSP1-REM**-BUF**			RSP1-REM**-COND-STS**	
AUTO CONTROL MODE	PSMD-B01-RSP1-**AUT**	B01-RSP1-AUT**-RAW**	RSP1-AUT**-BUF**			RSP1-AUT**-COND-STS**	
DUTY1 SELECT (OPERATOR INPUT VIA SCADA)							
DUTY1 SELECT (OPERATOR INPUT VIA OIT)							
VARIATION							
DUTY SELECTION (WHERE DUTY No. IS ASSIGNED)							
START COMMAND (AUTO PROGRAM)							
START COMMAND (OPERATOR INPUT VIA SCADA)							
START COMMAND (OPERATOR INPUT VIA OIT)							
ELAPSE TIME METER							
UNCOMANDED START							
UNCOMANDED STOP							
LOCKOUT							
LOCKOUT RESET							
SETPOINT SETTING (OPERATOR INPUT VIA OIT)							
SETPOINT SETTING (OPERATOR INPUT VIA SCADA)							
SETPOINT							
DUTY1 START REQUEST							
DUTY1 STOP REQUEST							
PSMD-B01-PAV1 (Valve)							
OPEN LIMIT SWITCH	PSMD-B01-PAV1-**OPD**	B01-PAV1-OPD**-RAW**	PAV1-OPD**-BUF**			PAV1-OPD**-COND-STS**	
CLOSED LIMIT SWITCH	PSMD-B01-PAV1-**CLD**	B01-PAV1-CLD**-RAW**	PAV1-CLD**-BUF**			PAV1-CLD**-COND-STS**	
VALVE POSITION	PSMD-B01-PAV1-**ZI**	B01-PAV1-ZI**-RAW**	PAV1-ZI**-BUF**			PAV1-ZI**-COND-FLTR**	PAV1-ZI**-COND-EGU**
VARIATION							
VALVE POSITION (VIA MODBUS)				B01-PAV1-ZI-**FBD-BUF**	PAV1-ZI-**FBD-EGU**		
VALVE OPENED STATUS (VIA MODBUS)				B01-PAV1-DIR-**FBD-BUF**	B01-PAV1-OPD-**FBD-STS**		
VALVE POSITION CONTROL COMMAND (NORMAL ANALOG OUTPUT)							
VALVE POSITION CONTROL COMMAND (MODBUS OUTPUT)							
OPEN REQUEST							
OPEN COMMAND (OPERATOR INPUT VIA SCADA)							
PSMD-B01-RSM1 (Flowmeter)							
FLOW SIGNAL	PSMD-B01-RSM1-**FI**	B01-RSM1-FI**-RAW**	RSM1-FI**-BUF**			RSM1-FI**-COND-FLTR**	RSM1-FI**-COND-EGU**
FLOW TOTAL							
DEBOUNCE ON TIMER (control word %R0001)						RSP1-RN-**COND-DBON-TMR**	
DEBOUNCE OFF TIMER (control word %R0001)						RSP1-RN-**COND-DBOF-TMR**	
TIMER PRESET VALUE						**%R0001-TMR-PV**	
TIMER CURRENT VALUE						**%R0001-TMR-CV**	

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	ANALOG STATISTICAL PROGRAM BLOCK	**DUTY** SELECTION PROGRAM BLOCK (ACP)			**PID** PROGRAM BLOCK		
EQUIPMENT TAG EXAMPLE:							
PSMD-B01-RSP1 (Pump)							
RUN CONTACT							
OVERLOAD CONTACT							
GENERAL ALARM CONTACT							
FORWARD RUN CONTACT							
REVERSE RUN CONTACT							
FAILED CONTACT							
FAULT CONTACT							
REMOTE CONTROL MODE							
AUTO CONTROL MODE							
DUTY1 SELECT (OPERATOR INPUT VIA SCADA)		RSP1-DTY1-**HMI**	RSP1-DTY1-**DTY-SEL**	RSP1-DTY1-**DTY-STS**			
DUTY1 SELECT (OPERATOR INPUT VIA OIT)		RSP1-DTY1-**OIT**	RSP1-DTY1-**DTY-SEL**	RSP1-DTY1-**DTY-STS**			
VARIATION							
DUTY SELECTION (WHERE DUTY No. IS ASSIGNED)		RSP1-**DTY-HMI**	RSP1-**DTY-SET**	RSP1-**DTY-ASN**			
START COMMAND (AUTO PROGRAM)				RSP1-ST-**DTY-REQ**			
START COMMAND (OPERATOR INPUT VIA SCADA)							
START COMMAND (OPERATOR INPUT VIA OIT)							
ELAPSE TIME METER							
UNCOMANDED START							
UNCOMANDED STOP							
LOCKOUT							
LOCKOUT RESET							
SETPOINT SETTING (OPERATOR INPUT VIA OIT)							
SETPOINT SETTING (OPERATOR INPUT VIA SCADA)							
SETPOINT							
DUTY1 START REQUEST							
DUTY1 STOP REQUEST							
PSMD-B01-PAV1 (Valve)							
OPEN LIMIT SWITCH							
CLOSED LIMIT SWITCH							
VALVE POSITION							
VARIATION							
VALVE POSITION (VIA MODBUS)							
VALVE OPENED STATUS (VIA MODBUS)							
VALVE POSITION CONTROL COMMAND (NORMAL ANALOG OUTPUT)					PAV1-**PID-CO**	PAV1-ZC-**PID-SET**	PAV1-ZC-**HMI**
VALVE POSITION CONTROL COMMAND (MODBUS OUTPUT)					PAV1-**PID-CO**	PAV1-ZC-**PID-SET**	PAV1-ZC-**HMI**
OPEN REQUEST							
OPEN COMMAND (OPERATOR INPUT VIA SCADA)							
PSMD-B01-RSM1 (Flowmeter)							
FLOW SIGNAL							
FLOW TOTAL	RSM1-FI-**ANST-TOT**						
DEBOUNCE ON TIMER (control word %R0001)							
DEBOUNCE OFF TIMER (control word %R0001)							
TIMER PRESET VALUE							
TIMER CURRENT VALUE							

EQUIPMENT TAG EXAMPLE:	AUTO PUMP CONTROL **SEQ**UENCE PROGRAM BLOCK		**DRIVER** PROGRAM BLOCK		**OUT**PUT BUFFER PROGRAM BLOCK
PSMD-B01-RSP1 (Pump)					
RUN CONTACT					
OVERLOAD CONTACT					
GENERAL ALARM CONTACT					
FORWARD RUN CONTACT					
REVERSE RUN CONTACT					
FAILED CONTACT					
FAULT CONTACT					
REMOTE CONTROL MODE					
AUTO CONTROL MODE					
DUTY1 SELECT (OPERATOR INPUT VIA SCADA)					
DUTY1 SELECT (OPERATOR INPUT VIA OIT)					
VARIATION					
DUTY SELECTION (WHERE DUTY No. IS ASSIGNED)					
START COMMAND (AUTO PROGRAM)					
START COMMAND (OPERATOR INPUT VIA SCADA)			RSP1-**ST-HMI**	RSP1-ST-**DRV-CMD**	RSP1-ST-**DO**
START COMMAND (OPERATOR INPUT VIA OIT)			RSP1-**ST-OIT**	RSP1-ST-**DRV-CMD**	RSP1-ST-**DO**
ELAPSE TIME METER				RSP1-**DRV-ETM**	
UNCOMANDED START				RSP1-**DRV-UCST**	
UNCOMANDED STOP				RSP1-**DRV-UCSP**	
LOCKOUT				RSP1-**DRV-LKO**	
LOCKOUT RESET				RSP1-**DRV-LKRST**	
SETPOINT SETTING (OPERATOR INPUT VIA OIT)	RSP-DTY1-**STLVL-HMI**	RSP-DTY1-STLVL-**SEQ-SET**			
SETPOINT SETTING (OPERATOR INPUT VIA SCADA)	RSP-DTY1-**STLVL-OIT**	RSP-DTY1-STLVL-**SEQ-SET**			
SETPOINT		RSP-DTY1-STLVL-**SEQ-SPT**			
DUTY1 START REQUEST	RSP-DTY1-ST-**SEQ-REQ**				
DUTY1 STOP REQUEST	RSP-DTY1-SP-**SEQ-REQ**				
PSMD-B01-PAV1 (Valve)					
OPEN LIMIT SWITCH					
CLOSED LIMIT SWITCH					
VALVE POSITION					
VARIATION					
VALVE POSITION (VIA MODBUS)					
VALVE OPENED STATUS (VIA MODBUS)					
VALVE POSITION CONTROL COMMAND (NORMAL ANALOG OUTPUT)					B01-PAV1-ZC-**AO**
VALVE POSITION CONTROL COMMAND (MODBUS OUTPUT)					B01-PAV1-ZC-**RO**
OPEN REQUEST	PAV1-OP-**SEQ-REQ**			PAV1-OP-**DRV-CMD**	B01-PAV1-OP-**DO**
OPEN COMMAND (OPERATOR INPUT VIA SCADA)			PAV1-OP-**HMI**	PAV1-OP-**DRV-CMD**	B01-PAV1-OP-**DO**
PSMD-B01-RSM1 (Flowmeter)					
FLOW SIGNAL					
FLOW TOTAL					
DEBOUNCE ON TIMER (control word %R0001)					
DEBOUNCE OFF TIMER (control word %R0001)					
TIMER PRESET VALUE					
TIMER CURRENT VALUE					

PART 6 PLC ALGORITHMS

6.01 Standard Modules

Standard device/process algorithms shall be used to link field equipment I/O to high-level automatic control strategies and to manual operator actions. The algorithms use registers and ladders in a consistent manner in each PLC and thus are highly portable and maintainable.

These functions performed by these algorithms (or modules) shall be all encompassing such that all PLC programming shall consist of simply assembling programs based from program blocks included in this library. Block functions can perform many functions; the following list is intended to provide guidelines to assist in determining what constitutes a module.

1. An interface module may be used to maintain status registers in the PLC memory for a device and providing the interface between operator actions, automatic control strategies and control outputs.
2. A control logic module may adjust process outputs based upon changes in field status and operator set points.
3. An input may perform the function of debouncing analog input data and converting the values to engineering units for use by a control block.

6.02 Specific Modules

This section will expand as new library entries are developed. At this time the following algorithms have been developed.

1. DeviceNet Communication Subroutine – DEV_NET.
2. Profibus Communication Subroutine – PROFIBS.

The following information shall be included in the functional description of new modules submitted for review.

1. Overview – Provides a general Description of the function performed & theoretical basis for control logic behind the module.
2. Control – Details the function of the algorithms (in the case of a device control block, this will be subdivided into control modes such as Auto, Manual and Local)
3. Failure Response and Lockout – Describes how the algorithm determines if the process is not responding in the desired fashion and how does the algorithm respond.
4. Control Mode Transfer – Describes how the algorithm behaves when modes change (e.g. bump-less device operation or transition through stop).
5. Presets – Lists all preset control settings and dead-bands.
6. Tuning – Describes the procedures to be followed to configure/customize the module for a given application.

PART 7 SCADA PROGRAMMING

7.01 Common

(a) General

This section describes the configuration standards to be followed when developing SCADA applications. SCADA applications include the operator display, SPC system and data historian.

7.02 Application Framework

(a) General

The programming of SCADA is object oriented in that each device or system is represented as an object containing all relevant attributes. The attributes represent device conditions, such as statuses and faults, as well as control points, such as start and stop commands. These attributes are associated with registers in the PLC.

Base object templates define device types, such as a pump or valve, and additional templates can be derived from these base templates to incorporate attributes that are not a part of the base template. Many field devices of the same type contain the same attributes and template objects allow a library of device types to be created that represent all field devices. Any modifications made to base templates or any parent template is propagated to all derived templates.

Each instance of a device is derived from an object template and immediately provides attributes associated with the device.

(b) Water Works

The City of London’s water system has been divided into the following control system modules.

1. Arva WPS & Area
2. Pond Mills WPS & Area
3. Springbank WPS & Area
4. Westmount WPS & Area

(c) Sewage Works

The City of London’s sewage system has been divided into the following control system modules.

1. Adelaide PCP & Tributary PS (exc. Medway System)
2. Greenway PCP & Tributary PS (exc. Medway & Dingman Systems)
3. Greenway Incinerator
4. Medway PS & Tributary PS
5. Dingman PS & Tributary PS

6. Oxford PCP, Southland PCP & Tributary PS
7. Pottersburg PCP & Tributary PS
8. Vauxhall PCP & Tributary PS

7.03 Program Logic

(a) General

During SCADA development, the following guidelines are to be followed.

1. The following SCADA real-time attributes are to be developed.
   - ✓ Discrete inputs are required for every available point of digital information available over the network (both from the PLC & from devices directly connected to the network).
   - ✓ Discrete outputs are required for field resets, and discrete device commands.
   - ✓ Analog inputs are required for every analog parameter available from the field.
   - ✓ Analog outputs are required for every process setpoint and limit that the operator can change from the displays.
2. As the PLC scales all connected analog values, Raw to EU scaling for these values is 1:1. Analog information provided directly from field devices will be scaled at the device level.
3. SCADA object and attribute names are to consist of the field I/O descriptor with the addition of standardised tagname suffix. The naming standards for generation of these names are described within the City of London standards.
4. All comment fields, item descriptions, etc. available within the SCADA to provide internal documentation of the application, will be completed in as meaningful a manner as possible.
5. Scripts are to be kept as simple as possible performing only a single task. Comments will be included in the script that clearly defines the logic for transitions between sequence steps. Logical sequences subdivided into well-defined series of simple steps with each step commented.
6. Where the same logical task is to be performed on multiple values subroutine call blocks will be developed and used to avoid duplication of similar logic.
7. Under no circumstance will SCADA Scripts, including PC control based advanced process optimization and tuning logic, be used in such a fashion that the loss of communications with the PLC will hamper the ability for the PLC to safely control the process.
8. Objects such as bar charts and real time trends will be configured such that associated attributes (max value, min value, units & time base) can be adjusted from an analog object control screen so periodic (e.g. seasonal) changes can be made to ensure that ranges are suitable for current operating conditions.
9. Objects such as bar charts and real time trends will be configured such that associated attributes (max value, min value, units & time base) can be adjusted from an analog object control screen so periodic (e.g. seasonal) changes can be made to ensure that ranges are suitable for current operating conditions.

7.04 SCADA Displays

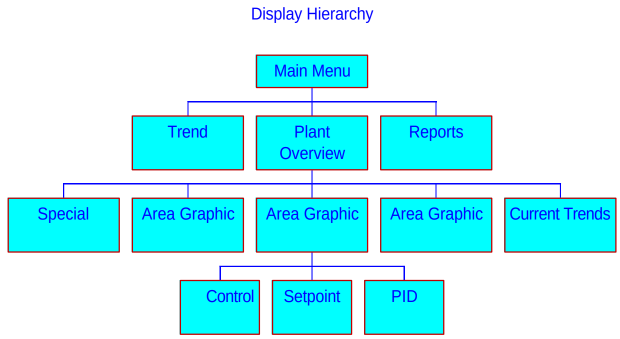
(a) General

SCADA displays shall provide the operator with plant-wide monitoring, control, alarming and access to historical data (historical trending) both of the overall process and of each piece of equipment that is involved with the process. The following requirements set forth a framework to provide consistency across applications.

1. The following details pertaining to screen development are contained in other City of London Standards sections.
   - ✓ Colours for piping and chemical systems
   - ✓ Colours for display of dynamic information
   - ✓ Colours to differentiate function of dynamic buttons
   - ✓ Colours for the differentiation of alarm status
   - ✓ Standard symbols to be used for all devices (fully ISA compliant), buttons, icons, etc.
2. The following screen types shall be generated. In some cases the screen type corresponds to a single screen – in other cases the screen type refers to a set of screens.

Screen Type	Description
Main Menu	Overview of the entire system or map of the area.
Plant Overview	Overview of each facility providing navigation links to specific processes.
Process Detail	Detail of a process or equipment grouping
Performance Monitor	This screen shall provide detailed SPC charting of all the performance monitoring criteria set forth within the process narratives
Electrical / Power Summary	Single line drawing showing status of all major breakers, etc.
Communication Summary	Schematic showing status of all network devices (PLCs, SCADA Nodes, etc.) and control/function performed by/interfaced through each device Tables providing detailed diagnostic information for all communications links within the system
Control Set-points	Listing of all control set-points, recipe control, and analog display controls
Security Configuration	Configuration of security profiles for each user class
Alarm Set-points	Listing of all alarm set-points and alarm control
Active Alarms	Listing of all alarms with scroll bars
Alarm Historian	Access to alarm and event statistics such as frequency & duration. Allows an operator to filter alarms based on alarm groups, priority, etc. Also allows alarms to be searched for specific text strings and allows operators to add comments and hotlink alarms to specific trends.
PDF View	View of operations manuals and control philosophy manuals
Pop-ups	Device settings

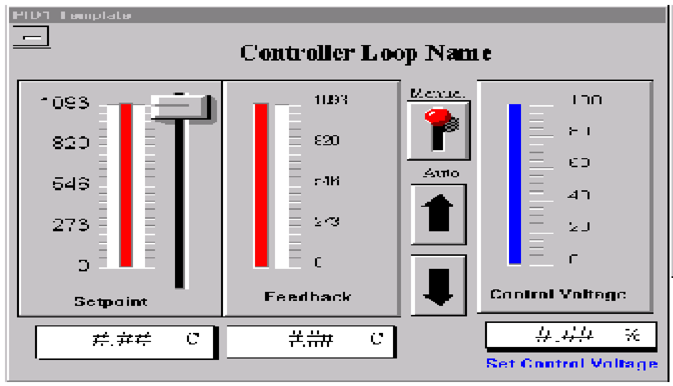
3. Operator graphic displays will be organised in the structured hierarchy shown below.



4. The Main Menu is a graphical overview of the entire system providing navigation links to the various facility groupings. The Plant Overview provides navigational links to the individual process screens and displays the status of the most important analog values monitored by the PLCs. The Plant Overview display corresponding to the facility grouping corresponding to the location of the SCADA node shall be the screen displayed upon startup.
5. Area graphics provide detailed overviews of all equipment and process data monitored and/or controlled by PLCs within an area of the plant. Examples of area overview displays are Section 1 Primary Clarifiers and Aeration. In addition to depicting the status of equipment, links are provided to the control popup windows.

6. On overview screens, process piping on the screen will be restricted to that which is critical to controlling the operation of the system. Area graphic screens will show all process piping and control devices.
7. Hotlinks will be linked to each device that will call the control display for that device.
8. Control displays consist of popup windows, which overlay the area graphic display when in use, and provide control for specific devices. Device control shall conform to the following guidelines.
   - ✓ All operator input fields will support graphical data entry (e.g. pick boxes, scroll bars, etc.) such that all control activities can be performed without the need for a keyboard.
   - ✓ Maximums and minimums will be defined for all analog set-point inputs and operators restricted to only entering values between these limits.
   - ✓ For critical equipment, the control action will call another small popup display that will require the operator to verify that the control action is desired.
   - ✓ The operator sets equipment to manual or automatic mode from the control displays. Equipment must be in automatic in order for the PLC to automatically start/stop, open/close, adjust speed, or otherwise adjust equipment operation without operator intervention.
   - ✓ Device control pop-up windows will display the following information.
     - Status
     - Mode
     - Number of running hours

- Number of cycles (start/stop, open/close)
- Standard alarms and alarm state
- CMMS Equipment Identifier Code



- ✓ PID controller is a special case of control popup window. The PID must be in “AUTOMATIC” for the PLC to maintain the process variable at the setpoint by automatically varying the control output. The PID cascade must be on for a PID to get its setpoint from a source other than direct operator-entry (e.g. from another PID). The operator must put the PID in Manual to set the control output manually. The operator must put the PID cascade in off to directly enter a setpoint.

9. The setpoint display provides a single location for operators to view and adjust all setpoints and control modes necessary to operate the automatic control strategy. The setpoint display is called from the Area Graphic by clicking on a screen button specifically for this purpose.
10. Trend displays give the operator a graphical representation of process variables. When the trend display is called from the process area display the display automatically displays the most common set of trend points. When called from the main menu, the trend display opens with a clear tend window ready for the operator to create a custom trend.
11. The alarm summary display in addition to providing the operator with a listing of all recent alarms reported to the SCADA workstation as presented on the alarm banner provides access to all additional alarm history and summary information as set forth in the sections describing the alarm management system
12. The performance monitor screen displays all performance indicators using standard Statistical Process Control (SPC) charts. These charts will be configured to display the performance indicator along with upper and lower control limits.
13. The following general screen development guidelines apply to all screen development
    - ✓ All dynamic information on screens will be driven by information provided by field devices. Operators will not be able to change the display status of any device except by changing the actual field state of that device (i.e. no assumed states will be displayed).
    - ✓ All screens will be developed such that functionality is fully compliant with Microsoft Windows standards defining how popup windows, scroll bars, push buttons, mouse buttons, etc. behave.
    - ✓ The operator interface shall consist of separate tiled windows as follows.

- Top tile reserved for screen navigation controls
- Centre tile used for specific information (note that this is the only window which will be available for WEB based viewing)
- Bottom tile reserved for alarm banner

✓ The alarm banner displays a list of the most current alarms.

✓ Operating status and/or position of all devices monitored by SCADA will be displayed by dynamic symbols (i.e. colour change).

✓ Devices that can be controlled by the SCADA will display a text message beside the device indicating field modes as either Local (controlled by the local panel) or Remote (controlled by the PLC) depending upon field switch position.

✓ Dynamic symbols are used to display all additional binary status information associated with devices monitored by the PLC.

✓ In addition to navigation by screen hotlinks, the following function key assignments shall be incorporated.

Button (Key)	**Action**
MENU (F1)	Calls the menu overview
OVERVIEW (F2)	Calls the graphic overview display
TREND (F3)	Calls the trend overview display
ALARM (F4)	Calls the alarm overview display
EXIT (F7)	Exits the display
CANCEL (F9)	Exits the control display without action
SETPOINT (F10)	Calls the set point display for the process
PREVIOUS (<)	Calls the previous process for the primary flow stream
NEXT (>)	Calls the next process for the primary flow stream

7.05 Alarm / Event Management

(a) General

The heart of the Supervisory Control system is the alarm and event management system. The following points prescribe design requirements for this portion of the system.

1. Under normal operation, the entire environmental services control system shall function as a single cohesive system. For example, when an alarm is acknowledged on one system, the alarm will be acknowledged on all systems on the network.
2. The primary communication server for each location will be defined as the primary alarm provider for the location. When the server is offline, each system will switch to a redundant server.
3. In addition to specific alarming requirements prescribed elsewhere, the system shall provide the following additional system alarms.

✓ Low system resources alarm

✓ Historian offline alarm

✓ I/O contradiction alarms (e.g. device reported open and closed)

✓ Communication status alarm for each communication link

✓ SCADA Communication Server offline

- ✓ SCADA Network Faults
- ✓ The following PLC Faults
  - Real time clock not synchronized
  - Rack faults
  - Low battery
  - Loss of communication
  - IO Faults (e.g. serial communication error)

4. An alarm banner shall be displayed at the bottom of the operator interface. The banner shall conform to the following requirements.
   - ✓ The most recent active unacknowledged alarms will be displayed at the top of top of the alarm banner.
   - ✓ The alarm banner shall indicate the date, time and description of the alarm condition.
5. Alarms shall be divided into the following logical alarm groups and subgroups and by facility.
   - ✓ Critical Alarms – triggered by conditions where events which have the potential to result in damage to the persons, environment, property or equipment without immediate intervention. Critical alarms result in a pop-up window being displayed describing the alarm condition and the significance of the alarm
     - Class 1 – PLC Driven – the operator must acknowledge these alarms. As these alarm function independent of the SCADA – it must be possible to acknowledge these alarms by local PLC connected reset buttons in addition to through the SCADA. These alarms will remain in Alarm State in the PLC until acknowledged at the SCADA level.
     - Class 2 – SCADA Driven – similar to Class 1 alarms but are not relevant when the SCADA is offline. The SCADA software, independently of the PLC, manages these alarms.
   - ✓ Warning Alarms – Warning alarms do not require immediate operator intervention and hence do not trigger plant alarm horns. However, they remain posted on the alarm banner until acknowledged.
   - ✓ Events (Information Only) - Events record useful information about the normal operation of the system (e.g. the start and completion of a filter backwash). Events do not appear on the alarm banner. Events are subdivided into the following categories.
     - Compliance - Records information associated with Health and Safety requirements.
     - Environmental – Records issues associated with the site’s operating license.
     - Operator Actions – Records relevant operational changes such as operator changes to set points.
     - Operational – Records all other.

6. Where PLC based alarm conditions are used for interlocks and/or to drive alarm horns connected at the PLC level the alarm registers to be monitored by the SCADA system for alarm status shall be the same as the registers used by the PLC for related control functions.
7. Alarms, which may be falsely triggered due to communication failures, will be masked to allow an opportunity for communication to be re-established. The time period to be masked shall be adjustable.
8. When communication problems result in total lack of communication to a field controller, all site alarms associated with the specific controller will be disabled and a single critical alarm indicating communication failure with the specific controller.
9. In order to assist operations staff with reviewing proposed alarms a configuration table similar to the following shall be completed for all alarms. Note that rather than providing a separate table for discrete alarms, these alarms are to be entered as if the field "trigger-point" level was a programmed analog value (e.g. "high bearing temperature" could be listed as a hi level alarm with a value equal to the temperature switch setting).

Tagname	**Description**	**Classification**		**Settings**										**Historical**	Operator Control		
		Group	Priority	LoLo		Lo		Hi		HiHi		Deadband		**Log**	Adjust Level		Disable
				Level	Page	Level	Page	Level	Page	Level	Page	Value	Time	**Duration**	Lo	Hi	

10. In order to ensure that alarms can be managed effectively, a detailed plan shall be developed and reviewed with the City of London describing alarm group hierarchy and alarm priority assignment. Charts along the lines of the following will be prepared to demonstrate the concept to the City of London.

	System	**Facility**	**Controller**	**Group**	**Sub Group**
$System	Adelaide	Adelaide	RPU1	Alarms	Critical Type 1
					Critical Type 2
					...
				Events	...
			RPU2	Alarms	…

Alarm Priority Assignment

Priority 1## – Long Term Storage

Priority 2## – Short Term Storage

Priority #1# - Not Paged

Priority #2# - After-hours Paged

Priority #3# - Always Paged

11. In conjunction with developing these relationships, requirements for grouping shall be defined and a document describing these concepts prepared and reviewed by the City of

London. Factors to be considered include the ability to treat alarm as groups (e.g. if door alarms are grouped, they can easily be enabled/disabled depending upon time of day), filtering of alarms for historical analysis, etc.

7.06 Alarm Configuration in SCADA

(a) General

Alarms originating from field contacts or generated by software shall be displayed at operator stations (if present) and central operator stations. The following table shows configuration by alarm priority.

Priority	Pop-up Window	Computer Audible	Pager	Alarm Summary	Alarm Filter	Hist Log	On Graphics
1	Yes	Yes	Yes	Yes	-	Yes	Yes
2	-	-	Yes	Yes	Yes	Yes	Yes
3	-	-	-	Yes	Yes	Yes	Yes
Event	-	-	-	-	N/A	Yes	Yes

Notes:

- Pager and alarm acknowledgements will be restricted to only authorized individuals.

The pop-up window fills about a quarter of the display screen and contains the alarm description, date and time of occurrence and the current status. The window should also list response actions or else provide a button to select response directions and help.

7.07 Security

(a) General

Security will be managed as a single integrated cohesive system with all assignment of privileges to individual users managed by the operating system. The following describes how security will be managed within the SCADA system.

1. Since user authentication will be performed by the operating system (e.g. Windows), the following steps define the process followed by the SCADA application when a new user logs in.
   - ✓ If not currently running, the SCADA view application will automatically start.
   - ✓ The SCADA view application will obtain network user group information from the operating system, and adjust user privileges accordingly.
   - ✓ Unless the user has appropriate security clearance for access to the operating system, the graphical environments control bar, menu box and navigation hot keys (e.g. Ctrl-Alt-Del) shall be disabled.
2. Upon logging in, the operating system will assign individuals to one of the following user groups. The SCADA will in turn assign the user the listed privileges
   - ✓ _SystemAdmin – As system administrators, individuals in this group will have all privileges granted to individuals in other groups plus full local system level rights,

ability to modify user accounts, make system level modifications, etc. Runtime control of field devices and access to control setpoints is not available.

- ✓ _SystemConfig – Individuals in this group will be provided the same privileges excepting the ability to modify security and user account. Runtime control of field devices and access to control setpoints is not available.
- ✓ _SystemDevelop – Individuals in this group are provided the privileges required for development of system objects and area structures as well as the ability to test device control and function in a controlled environment. Runtime control of field devices and access to control setpoints is not available.
- ✓ _pScadaSupervisor – As supervisors individuals in this group will have all the rights granted for full runtime control plus the ability to change all adjustable set points and alarm levels. No system level control or configuration is available.
- ✓ _pScadaCO – This group is designated for individuals in the Chief Operator position. These individuals are provided most of the same privileges as Supervisors with the exception of abilities to change certain alarm and adjustable setpoint levels. No system level control or configuration is available.
- ✓ _pScadaOperator1 – As operator level 1 individuals in this group will be able to change limited number of set points and alarm levels, starting and stopping of equipment, changing duty queues and various other operational activities. Individuals at this level will be restricted in access to the control screens within the SCADA application – direct access to the operating system will be restricted. Within this group, individuals may be further restricted to controlling only a limited number of facilities.
- ✓ _pScadaOperator2 – As operator level 2 individuals in this group will be able to change limited number of set points and alarm levels, starting and stopping of equipment, changing duty queues and various other operational activities. Individuals at this level will be restricted in access to the control screens within the SCADA application – direct access to the operating system will be restricted.

3. If a node is not used for a pre-specified period of time, the current user will be automatically logged out.
4. Users will be able to log onto any SCADA control computer on the network and gain the ability to perform those tasks for which they have been granted privileges.
5. If an individual with a valid City of London user account, but who is not a member of one of the previously described network user groups, logs onto a control node they will be automatically launched into the SCADA view application. They will be able to move around in the system and view all normal operational information. The ability to control devices, change parameters, acknowledge alarms, generate reports, view custom trends, access the operating system, etc. will be prevented. For the purposes of this document, this level of security will be referred to as “Guest”.
6. If an individual logged in attempts to perform an activity that they do not have sufficient rights to perform a pop-up message will be posted indicating the level of security they are currently logged in with and the level of security required in order to perform the activity.

7.08 Historian

(a) General

The Historian systems are to manage all historical data (alarms, events, trends, SPC data, etc.) and function as the primary IO servers for the SCADA system. The following provides general direction on how the Historian is to function.

1. The Historian system will be configured to function solely as a data management suppository. It will not be used as operator interfaces or perform any non-SCADA functions.
2. The primary Historian located at Greenway will be configured in a hot redundant configuration based on Microsoft server clustering technology.

(b) Trending

The following details how the Historian is to manage historical trend information.

1. The Historian will manage all trend information. No information will be logged locally on the SCADA control nodes.
2. When an operator requests that information for a specific trend be displayed on a control node the information will be requested from the Historian transparent to the operator.
3. Pumping Station information will be logged to the Historian from the plant to which it pumps.
4. The system shall automatically stop logging information when the value is under range.
5. In order to assist operations staff with the review process, a trending configuration table similar to the following shall be provided before programming commences.

Tagname	**Description**	**Valid Range**			**Deadband**		**Historical Summary Generation**							
		Min	***Max***	***Units***	***Value***	***Time***	***Hourly***				***Daily***			
							Min	*Max*	*Avg*	*Total*	*Min*	*Max*	*Avg*	*Total*

Deadband - Value is absolute (e.g. +/- 0.05m) and typically derived from instrumentation accuracy, time is required sample resolution

Disable - Auto disable works by value falling outside of valid range, manual is operator selectable

(c) Operational Reports

The following outlines the historical report generation requirements to be provided as part of control system design.

1. Reporting requirements are limited to generation and verification of the SQL summary tables necessary to generate the following reports. The City of London will generate actual reports from the information in these tables.
   - ✓ Monthly filter summary;
   - ✓ Annual filter summary;
   - ✓ Monthly equipment runtime;
   - ✓ Annual equipment run-time;

- ✓ Monthly chemical usage;
- ✓ Annual chemical usage;
- ✓ Monthly operational;
- ✓ Annual operations;
- ✓ Analytical summary;
- ✓ MOEE compliance reports.

The data verification process to be followed will provide a process to verify information collected by the SCADA system before the information is transferred to the City of London's data archive.

(d) Historical Alarm & Event Log

The Historian will manage all historical alarms and events. The following outlines the primary functional requirements.

1. Historical alarms and events not specifically identified as requiring long term storage will be erased automatically after 90 days.
2. As soon as an alarm occurs an alarm record will be generated within the historical alarm management system. The record will track the time of occurrence, time of acknowledgment, and name of the individual who acknowledged the alarm.
3. Operators will be able to filter alarms and events with an operator definable filters including specific text string occurrence, date and time, priority, alarm group, etc.
4. Once a specific alarm is identified the operator will be able to add comments to the alarm.
5. Historical alarms will be logged Historian servers at Greenway, which will provide long term historical alarm management.

(e) Other SQL Functionality

The following SPC functionality is to be incorporated.

1. All process performance indicators are to be tracked within the SPC system with appropriate control limits set such that operators are able to identify and rectify operational inefficiencies.
2. Where statistics based alarms such as rate of change and degree of deviation alarms are required, these alarms will be generated by the SCADA SPC component to ensure that they are properly calculated.
3. A similar table to the trend configuration table is to be developed for SPC configuration identifying interrelationships between various parameters, control limits, etc.

The following additional functions are to be performed by the Historian.

1. SQL stored recipes will be used to manage SCADA control system settings & setpoints (e.g. adjustable alarm levels) such that the information is readily accessible to control nodes when they are initialized.
2. SQL stored recipes will be provided which backup PLC totalizers, settings & setpoints (e.g. adjustable alarm levels, runtimes, etc.) and allow this information to be easily restored from the SCADA system if a PLC should fail.

7.09 Alarm Paging

(a) General

The following information provides details with regards to how the alarm paging system is to function.

1. Alarm paging will be triggered based on the HIHI and LOLO alarm limits set within the SCADA View module.
2. Alarms will be grouped and all alarms within a group will be paged to a specific list of individuals. The individuals within this prescribed list are the only individuals who will be able to acknowledge the alarms that are assigned to this group.
3. When an individual dials into the system they will be required to acknowledge each alarm individually and will be able to check the current values for key operating parameters such as certain control levels.
4. It shall be possible to acknowledge alarms by calling the paging computer directly. This will acknowledge the alarms at the SCADA view interfaces as well as within the paging module.
5. If an alarm is cleared at an SCADA control node, the alarm paging will cease.
6. Alarm dialer configuration information is to be presented in a tabular fashion in order to aid operational review and understanding. The following tables provide a sample of how this information may be tabulated.

Common Settings	
# of Retries	?
Time between Retries (seconds)	?

Time Period Active	?	To	?

	Delay (sec)	**1st Page**	**2nd Page**	**3rd Page**
Group A				
Individual Alarms	?	?	?	?
General Alarm	?	?	?	?
Group B				
Individual Alarms	?	?	?	?
…				

7.10 WEB Server Configuration & Implications

(a) General

The WEB server is intended to provide a real-time window for management and supervisory personnel to view process conditions, and Historian information. The following provides details regarding how this system is to be setup.

1. The graphic screens will be a subset of the screens developed for the SCADA control nodes and will be imported from the finished SCADA control application.
2. Since the following graphic screens generated for the SCADA control nodes will be exported for WEB display, they will be designed so they can be easily converted to

XML. Information, which cannot be easily converted, will be located on the top and bottom banner (i.e. alarm banner & navigation banner) or on popup displays.

- ✓ Main Menu
- ✓ Plant Overview
- ✓ Process Detail
- ✓ Performance Monitor
- ✓ Electrical / Power Summary
- ✓ Communication Summary
- ✓ Control Set-points
- ✓ Security Configuration
- ✓ Alarm Set-points
- ✓ Active Alarms
- ✓ Alarm Historian

3. Windows will be designed as Script independent as possible (i.e. use of window and screen specific condition scripts will be avoided were possible).
4. Where possible, screens intended for conversion will be designed such that they may are suitable for display on low-resolution WEB clients such as WindowsCE handheld browsers.

7.11 Initialization, Fault Management & Recovery

(a) General

(b) Communication

The following details describe how the system is to respond to various communication problems.

1. Under normal operation information will be accessed through the primary local SCADA Server. When the primary server is offline, control nodes will automatically switch to obtaining data through the backup/redundant SCADA Server. If neither data source is accessible, the node will display a popup message indicating that the node is offline.
2. If a communication failure occurs between SCADA nodes the system will automatically attempt to reestablish communication while collecting data through the appropriate backup data provider. A system critical alarm will be generated indicating which node has failed.
3. Information will display last known state upon communication failure, however the value (or display item) will flash slowly to indicate that the accuracy of the information is questionable.
4. As a first level of monitoring, the quality of the data and communications links will be monitored using the software packages built in quality monitoring. Data quality information will be derived at the OPC driver level. This information will be used to drive communication status indicators on the respective graphic screens. Detailed status messages will also be displayed on the communication status screen.
5. As a second level of system health monitoring, a heartbeat will be programmed between the controller and the SCADA system to confirm full circle operation (the heartbeat shall consist of a register in the controller being incremented by the SCADA software

package, moved by the controller to another register, and then read back by the SCADA software). An alarm will be generated whenever the time delay exceeds a supervisor adjustable threshold. The current time delay for each link will be displayed on the communication diagnostic screen.

6. Communication errors will be tracked with regard to frequency of failure and total duration and displayed on the communication diagnostic screen.

(c) Start-up & Power Failure

Upon initial startup and following power interruptions the system shall respond as follows.

1. The PLC shall respond as follows.
   - ✓ Following a power interruption, the system shall pause following return of power to confirm power is stable. This pause shall be individually adjustable for each controller.
   - ✓ For manned facilities, the controller shall wait for operator intervention before restarting the facility.
   - ✓ For unmanned facilities, the controller will restart the facility without operator intervention.
2. The SCADA system shall respond as follows.
   - ✓ In the case of nodes, which are not running the alarm paging software, the system will automatically initialize itself, all services will start, and the system will wait at the login prompt for a user to login.
   - ✓ Nodes, which are running the alarm paging software, will upon booting automatically login and initialize the alarm dialler package.
3. For power outages not exceeding 90 minutes the control system will be maintained, in it’s entirety, on-line by UPS. Once the UPS has drained to 25% capacity, the system will automatically shut down in a safe and orderly fashion.

(d) Fault Tolerance

The following describes certain aspects of the fault tolerance that is to be designed into the system.

1. The failure of any portion of the system shall result in the posting of an alarm identifying the malfunctioning unit. The unit for the purposes of this clause is defined as node, server, application, service, PLC, etc.
2. Control Nodes that have the ability to connect directly to the PLC will retain limited functionality when the SCADA Servers are offline. Alarming will switch over to displaying only local alarms and historical trending will not be accessible. In addition to an alarm, a clear warning message will be posted on top banner indicating that the compute is functioning in standalone mode.
3. Upon loss of communication with the primary data provider, interface nodes will within sixty (60) seconds automatically switch over to an alternate data provider.
4. In order to allow a single build to be maintained for the various control nodes, the application will self configure based on Node Name.

PART 8 REVISIONS AND COMMISSIONING

8.01 Program Revision Control

(a) General

The following procedures will be followed during application development.

1. Each application will be stored in the system platform database
2. Normally individuals will only undertake development work (including modifications to configurations) on the application located on the system platform. Changes can be tested on a test application located on the system platform prior to changes to the main application. This test application can be deployed to a test node for verification of programming.
3. When modifications are complete, the application is to be checked in and a description of the changes provided during the check-in process. In the case of PLC programs, the application will either be loaded from the master directory on the network or copied to a notebook computer and loaded locally.
4. In the case of PLC programs, the updated version will be loaded to the master directory with the date of the current revision in the file name. eg.PCGW_RPU01_Jan1_08.
5. A backup will be generated on a weekly basis and will be located in a separate network directory. The intent is to ensure that reasonably current copies of all applications are accessible even during interruptions in network service.

8.02 Software Test Procedure

(a) General

Each software component (PLC & SCADA) shall be tested extensively with the simulation panel/test node to ensure that it works properly before field installation. As a minimum, the following verification steps are shall be completed.

1. All IO points are individually tested to verify field inputs, input buffering, and input conditioning.
2. All monitoring and control loops are verified from the field device through to the PLC data table and SCADA displays.
3. Each automated process control algorithm is extensively tested to verify proper operation.

The following additional requirements also apply.

1. All testing shall be performed on hardware of the same make, model and revision level as will be used once field installed. Written certification shall be provided in advance of the testing that the hardware and software used are in every way the same as what will be in place once field installed.
2. Ensure that the test bench topology adequately simulates the actual field installation in order to provide for meaningful testing. The proposed test bench topology (including system configuration, hardware models and options and software version) shall be reviewed with and approved by the Engineer before commencement of testing. Requested changes shall be incorporated at no additional cost to the project.

3. As a minimum, system tests shall demonstrate the following functionality:
   - ✓ System backup and restore;
   - ✓ Recovery from equipment failures;
   - ✓ Verify input/output point processing;
   - ✓ Communication between PLCs and remote I/O;
   - ✓ Change of state for a discrete input on a resulting change on the display;
   - ✓ Each unique control strategy used (verify against described strategy in control philosophy);
   - ✓ Alarm functions for analog and digital points;
   - ✓ Historical data access and statistical summary generation.
4. As a minimum, system tests shall demonstrate the following performance criteria:
   - ✓ Communication systems response times:
     - Remote I/O to area PLC;
     - PLC to process management computer;
     - PLC to operator station;
     - Operator station response times;
5. Accuracy of historical data collection;
6. Impact of change to daylight savings time on historical data collection;
7. Response to power outage and restoration.

The intent of simulation testing shall ensure the controls function as designed and meet all requirements set forth in all applicable City of London Standards. Tests should be designed in such a fashion as to catch as many strategy or tuning problems as possible.

Each test, which forms part of this verification process, shall be witnesses and signed off by the City of London.

PART 9 DOCUMENTATION

9.01 Common

(a) General

It is recognized that many systems will be in use within the Water and Wastewater systems. Each will be unique with respect to its software programming, documentation, configuration and communication. The intent of this component is to standardize on the minimum documentation required for each device.

In general each programmable device (including magnetic flow meters, level sensing units, smart pressure transmitters etc.) supplied shall include the approved commissioning procedure and programming software (if applicable) registered for use by the City of London.

A master communications drawing must be submitted to identify the device and its role in the communications path. Hard and soft copies of all upstream and downstream data mapping associated with the device are to be separately identified and presented in a standard spreadsheet format. The list of registers or data components utilized, as well as all unused registers or data areas must also to be identified within the spreadsheet summary.

Note: Equipment that requires special programmers or firmware requirements is not to be considered, (unless no other alternative solution can be found).

9.02 Software Licensing, Archiving & Maintenance

(a) General

The City of London SCADA team is responsible for software licensing, program and data storage, revision control, and notifying users of software updates. The following highlights the minimum requirements or approvals when implementing software-based solutions.

1. Software utilized must be approved by the SCADA team for the application proposed.
2. Program development will be in accordance with the City of London's standards for development, testing and implementation of software-based solutions.
3. Before loading any software or configuration on any device a copy of the program is to be submitted to the SCADA team where it will be provided with a revision number and made available on the City network on a read only basis.
4. When loading programs onto devices, the program that has been made available on the SCADA system network shall be downloaded and used as a working file. If changes are made, the updated program shall be resubmitted to the SCADA team within 24 hours of modification. The version available on the SCADA network will be updated the same business day, and the previous version will be archived.

9.03 PLC/RTU & Operator Interface Programming

(a) General

Separate program documentation is required for each PLC. The PLC's are to be identified and coded as per other equipment. The documentation shall comprise at least the following subsections:

1. Table of contents.
2. Hard and soft copies of the programs complete with process narrative descriptions on a rung-by-rung basis.
3. Identification of all acronyms used in both the hard and soft versions.
4. Listing, identification and summary of all registers and data tables (logic components) associated with the PLC programming environment. This list and summary is to be developed as a spreadsheet. All unused data registers or components are to be identified. Each component, i.e. analog in table (%AI), program register (%R) etc. shall be listed on separate sheet within the workbook file.

In addition to the requirements noted above, the following is required for all operator interfaces:

1. A list of all acronyms used.
2. Detailed description of software configuration details including full description of the coding structure used.

A spreadsheet summary listing and identifying each screen used and summarize unused screens.