CONTROL SYSTEMS

TMS1733 - GENERAL SPECIFICATION

Revision Table

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Contents

1 SCOPE

This Specification outlines the minimum technical requirements for Urban Utilities Control Systems.

This Specification is divided into four parts covering distinct topic areas:

1. General Requirements
2. Hardware
3. Software & Programming
4. Installation & Setup

Refer to the following for Contract requirements pertaining to the Works:

Work Type	Governing Contractual / Agreement Terms
D&C Contract	TEM547 unless superseded by an individual contract
Developer Services	Individual Approvals & Decision Notices for the works
Urban Utilities Delivery Framework	TEM641 Part B – Standard General Specifications

Except where explicitly stated otherwise, the requirements of this Specification shall be the responsibility of the Contractor as defined in Section 1.1.1 Definitions.

This Specification is further intended to complement the information contained in other Urban Utilities technical specifications and provide further clarity for requirements throughout the project life cycle

For detailed information regarding the design and installation of Electrical & Instrumentation equipment, including the physical installation of control system panels and field cabling, refer to TMS1732 *Electrical & Instrumentation General Specification*.

1.1 Definitions

In this document, the following definitions apply:

Term	Definition
Accountable party	The person nominated within an Inspection and Test Plan (ITP), verification document or procedure as being responsible for certifying completion of a task of step within the quality assurance process.
Project Documentation	Documentation that outlines the requirements of Urban Utilities infrastructure being established through a project. This documentation will form part of the agreement between Urban Utilities and the entity responsible for the development of the relevant infrastructure.

Term	Definition
Contractor	The entity responsible for the delivery, or part thereof, of the required infrastructure including design, manufacture, supply, installation and/or demolition. This may include, but is not limited to, a developer or the successful tenderer to a bid.
Contract	The agreement between Urban Utilities and the Contractor to which this specification pertains.
Design Life	The expected time period an asset is required to remain in service, taking into account asset duty, maintenance, environmental conditions and economic constraints
Hold Points	An identified point in the project life cycle at which an activity must not proceed without direction by the entity responsible for quality assurance
Shall	Where "shall" is used in this document, the associated requirement is a mandatory requirement
Works	The scope of work outlined in Project Documentation

Note that the above definitions are restricted to this document only.

1.2 Applicability

This specification applies to the design and construction of electrical works associated with water and wastewater infrastructure assets ultimately owned and operated by Urban Utilities, including donated assets.

The application of this specification by asset type is as follows:

- **Reticulation water supply & sewage service network** - SEQ D&C Code is applicable. Where SEQ D&C Code is silent with regards to the requirements for a particular design or construction element then the relevant Sections of this specification shall apply.
- **Trunk water supply & sewage service** - SEQ D&C Code is applicable through trunk main TMS. Where SEQ D&C Code is silent with regards to the requirements for a particular design or construction element then the relevant Sections of this specification shall apply
- **Pump stations** - SEQ D&C Code is applicable. Where SEQ D&C Code is silent with regards to the requirements for a particular design or construction element then the relevant Sections of this specification shall apply
- **Other Non-Reticulation Assets, including Treatment & Reservoirs** - this Specification is applicable without limitation

Where conflicts otherwise arise between the SEQ D&C Code and this specification, this specification shall take precedence.

2 GENERAL

2.1 Standards and Regulations

All design, equipment and workmanship shall conform to the most recent requirements of the relevant statutory Local, State and Commonwealth authorities and current applicable Australian Standards. Alternatively, where no Australian Standard exists, work shall conform to the most current and applicable International standard.

Where conflict exists between different applicable Codes, Standards or Regulations, the most onerous conditions of specification shall apply unless a specific hierarchy is defined in Project Documentation or if accepted otherwise in writing by Urban Utilities.

The provisions of the relevant standard shall not be deviated from without first obtaining agreement in writing from Urban Utilities.

Standards with specific application in the design, selection or installation of electrical equipment types are referenced in the text of this Specification. Broadly applicable standards and regulations relevant to the work include but are not limited to the following:

2.1.1 Australian Standards

Standard	Title
ANSI/ISA-18.2	Management of Alarm Systems for the Process Industries
AS 2700	Colour Standards for General purposes
AS/NZS 3000	Electrical installations (known as the Wiring Rules)
AS 4009	Software reviews and audits
AS 4761.1	Competencies for working with electrical equipment for hazardous areas (EEHA) – Competency Standards
AS 11801	Information technology – Generic cabling for customer premises
AS/NZS 60079	Explosive Atmospheres – All Parts
AS 60529	Degrees of Protection Provided by Enclosures (IP Code)
AS/NZS 61000	Electromagnetic Compatibility (EMC) – All Parts
AS IEC 61131	Programmable Controllers – All Parts
IEC 61158-1	Industrial Communication Networks – Fieldbus Specifications – Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series
IEC 62443-2-4	Security for Industrial Automation and Control Systems Part 2-4: Security program requirements for IACS service providers
IEC 62541	OPC Unified Architecture
IEEE Std 802.3	IEEE Standard for Ethernet
IEEE Std 1815	Standard for Electric Power Systems Communications – Distributed Network Protocol (DNP3)
AS 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems

Standard	Title
AS 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems

2.1.2 Industry Standards

The following industry communication protocols are applicable:

Protocol	Specification Reference
Profinet	www.profibus.com/download/profinet-specification/
Ethernet / IP	www.odva.org/Publication-Download
MODBUS	www.modbus.org/specs.php
DNP3	www.dnp.org/Resources/Public-Documents
IEC 61850	webstore.iec.ch/publication/6028
OPC	opcfoundation.org/developer-tools/specifications-unified-architecture

2.1.3 Acts and Regulations

Current regulations and statutory requirements of the State of Queensland, Australia, shall be complied with, including:

- Queensland Electricity Act (1994)
- Queensland Electricity Regulations (2006)
- Queensland Work Health and Safety Act 2011
- Queensland Work Health and Safety Regulations 2011
- Queensland Work Health and Safety Codes of Practice
- Queensland Environmental Protection Act - 1994 and Amendment Act – 1997
- Queensland Electrical Safety Act 2002 and its latest amendments
- Queensland Electrical Safety Regulations 2013
- Queensland Electrical Safety Code of Practice 2013
- Queensland Professional Engineers Act 2002
- Queensland Professional Engineers Regulation 2003
- Queensland Workers' Compensation and Rehabilitation Act 2003 and Amendment Act 2015
- National Construction Code 2016, volumes 1, 2, 3 and The Guide
- Australian Work Health and Safety Act 2011
- Australian Work Health and Safety Regulation 2011
- Australian Work Health and Safety Codes of Practice 2015
- Australian Telecommunications Act 1997
- Australian Radiocommunications Act 1992
- ARPANSA Radio Protection standard for Maximum exposure Levels to Radiofrequency Fields – 3kHz to 300GHz (2002)
- ACMA Radiocommunications (Analog Speech (Angle Modulated) Equipment) Standard

The following water industry codes shall be complied with:

- Water Supply Code of Australia SEQ Service Providers Edition
- SEQ WS&S D&C Code

The above referenced codes are found online at http://www.seqcode.com.au

3 DESIGN

3.1 General Design Requirements

3.1.1 Design Personnel

Engineering services undertaken in the delivery of Urban Utilities assets shall be in accordance with all legislative requirements, including the *Professional Engineers Act 2002 (Qld)*, as well as professional standards and rules governing the performance of professional engineering services in Queensland.

Personnel engaged for engineering design services shall be registered, suitably experienced, competent and skilled in the field of work in which they are engaged.

Engineering design deliverables shall be certified by the appropriate RPEQ at the following stages:

Stage	Application
Key milestones	Developer Services projects or where defined in Project Documentation
"For Construction"	All projects – refer PRO307
"As Built"	All projects – refer PRO307

Signatory name, RPEQ number and certification date shall be printed alongside all signatures.

3.1.1.1 Hazardous Area Design Competency

Urban Utilities requires that any persons who designs, constructs, erects or select electrical equipment in Hazardous Area installations is to be trained and competent in accordance with AS/NZS 4761 series of Standards.

Urban Utilities requires persons undertaking Hazardous Area design must have a minimum of 5 years relevant prior experience.

3.1.2 Design Goals

Equipment shall be designed to fulfil the following design goals in order of priority unless specified otherwise in Project Documentation:

- Safety of personnel

- Protection of plant and environment
- Ease of operation to meet process requirements
- Reliability and continuity of supply
- Maintainability
- Minimisation of overall capital and operating costs, including replacement costs
- Ease of future expansion and upgrade

3.1.3 Design Activities

Design includes the following activities:

- Design-related project management activities, including the development of a Design Management Plan (DMP)
- Investigation Work including the gathering, substantiation and verification of all information necessary to perform the design work including Urban Utilities stakeholder requirements
- Concept designs, including development of a Basis of Design, optioneering and early identification of safety, cost, constructability, operation and maintenance issues
- Design development to produce drawings showing the relationship of new plant to existing structures, plant and equipment, services, roadways and depth of cover
- Safety in Design actions intended to identify, review and incorporate measures to address safety, constructability, operation and maintenance risks
- Full detailed design including production of final certified design drawings and other technical documents
- Development of commissioning management plan with inspection and test plans (ITPs)
- Develop Equipment Changeover Plan
- Determine required equipment changeover period in consultation with Urban Utilities
- For Developer Services projects, milestone submissions refer to the Key Milestones document

3.1.3.1 Temporary Works Design

Temporary Works designs shall cover all new elements necessary for construction but intended for removal prior to final handover. Temporary Works design documentation shall be RPEQ certified and accepted by Urban Utilities before commencing installation works associated with the design.

Designs shall clearly indicate the method by which temporary designs will be used in construction.

3.1.3.2 Construction Design

Construction design comprises any required design detail not captured in "For Construction" Project Documentation or standard drawings. It shall capture the final element of design required to complete the installation and shall be completed as part of preparation for construction. Such design works shall complement and not contradict or modify the intent of the design as provided in the Project Documentation.

Construction design documentation shall be certified by an RPEQ and available for review by Urban Utilities before commencing installation works associated with the design.

Construction design shall include suitable sketches, schedules and descriptive information clearly identifying the information required for review.

3.1.4 Safety in Design

Safety in Design processes shall be incorporated into the design in order to reconcile safe design with full facility life and function. The design process shall ensure all Safety in Design requirements are addressed, including those prescribed in relevant acts, regulations, Australian standards and industry codes of practice.

The design shall identify, document and address all safety risks early in the design process. Where the design is not inherently safe, a safety in design process shall be undertaken. Risks identified shall be assessed and monitored as per PRO84 *Urban Utilities Risk Management Procedure*.

Refer to PRO662 *Safety in Design Procedure* for requirements regarding the implementation of Safety in Design at Urban Utilities, including Project Risk Assessments, as well as HAZID, HAZOP, CHAZOP and CHAIR workshops. For each project stage, a Safety in Design Report as per template TEM529 *Safety in Design Report* shall be produced to document and summarise the process.

3.1.4.1 Machine Safety

Machine safety principles as per AS/NZS 4024 shall be applied to machines or packages / assemblies of machines designed to work as a singular unit (e.g. belt filter press, step screens, settling tank bridges etc.). "Machine" in this context is defined as an assembly, fitted with a drive system consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application (e.g. a pump and coupled motor or a fan, but not a gas-fired boiler, an electric heater, a tank or a pipe system).

When selecting machines or assemblies of machines for use at Urban Utilities facilities, documentation must be available showing compliance with the relevant portions AS/NZS 4024 or its harmonised international equivalents as listed in AS/NZS 4024:1100 (note that many of these are also listed as part of Machinery Directive 2006/42/EC). Machine compliance to AS/NZS 4024 shall be confirmed as early in the equipment selection process as possible. Documentation shall explicitly name the standard(s) applied and may take one or more of the following forms:

- Documentation as per AS/NZS 4024.1201 summarising the risk assessment procedure followed, the results achieved, and the safety measures applied

- Declaration of conformity
- Third party certifications
- Test certificates

A machine safety risk assessment as per AS/NZS 4024:1201 (in addition to the requirements of PRO662 *Safety in Design*) shall be carried out for machines or packages / assemblies of machines being supplied where no documented compliance with AS/NZS 4024 or a harmonised international equivalent can be provided.

Specific requirements for complementary safety measures to enhance the safety of machines beyond AS/NZS 4024 mandatory requirements are outlined in the following sections.

3.1.4.2 Safety Instrumented Systems

Owing to their complexity and difficulty of integration with Urban Utilities' systems, the use of Safety Instrumented Systems (SIS) shall be avoided if the required safety performance can be achieved without their use. Where use of SIS is unavoidable the SIS shall comply with IEC 61508/61511.

3.1.5 Asset Numbering

Equipment, components and cables shall be assigned unique tag names and these shall be accepted by Urban Utilities. Tag names shall be assigned to existing equipment and cables if not already assigned, where the project scope of work requires interfacing new equipment with existing operational equipment.

Equipment, component and cable tag names shall be presented for acceptance early in the design process.

Refer to TMS1647 *Plant and Equipment Tag numbering specification.*

3.1.6 Documentation

Where applicable, documentation required for each stage will be advised via the project Deliverables Requirements List (DRL). Refer to CHE486 *Deliverables Requirements List DRL* for the types of documentation which may be required.

Documents (excluding drawings) listed on the DRL shall be provided with a standard Urban Utilities title page as per TMS1654 *Naming Requirements for Engineering Documentation*.

Submissions of documents to Urban Utilities shall be in accordance with PRO307 *Drafting and Drawing Management Guideline for Capital Project Delivery* and PRO395 *QUU Addendum to SEQ Water Supply and Sewerage Design and Construction Code (Asset Information Specification)*.

3.1.7 Exceptions

A list of deviations or exceptions to this Specification shall be submitted to Urban Utilities as early as possible and updated at each new stage of delivery. In the absence of any exceptions, it will be construed that this Specification is fully complied with.

If during design, planning or installation, circumstances arise wherein it appears that this Specification cannot be complied with or if an innovative or alternate approach is proposed, the proposed request for deviation meeting requirements set out in PRO752 shall be submitted to Urban Utilities in writing for approval. This shall include the following:

- Justification for why the Specification cannot be complied with and/or a description of the benefits of the alternate approach over the Specification and how it will be functionally equivalent to the Specification requirements
- Backing information (e.g. sketches, drawings, photographs, technical documentation, calculations etc.)

Backing information shall be sufficient for an engineering assessment of the deviation to be carried out. If insufficient information is provided, Urban Utilities may reject the proposal and request additional information.
Exceptions to the intent of Project Documentation shall be handled as per the approved process
within the project's governing framework.

3.2 System Design Requirements

3.2.1 Operation & Design Life

New equipment shall be designed for minimum design life duration as stated below for the intended environment and duty. New equipment shall also be suitable for normal continuous operation with only scheduled maintenance as specified by the component manufacturer.

COMPONENT	MINIMUM DESIGN LIFE
Control System Hardware	15 years
Cabling & Cable Containment Systems	50 years
Batteries	10 years

Control system hardware components will be operated continuously 24 hours per day, 365 days per year under the installed conditions. Equipment shall be designed to perform this duty safely without being attended.

3.2.2 Local and Environmental Conditions

Equipment and structures shall be designed and rated for the environmental conditions specified.

Selection of equipment shall take into account harsh conditions. These may include any one of or a combination of the following:

- Corrosive environment
- UV exposure
- High temperature
- Low temperature
- High humidity
- Dust
- Vibration
- Electromagnetic / radio frequency interference

Corrosive environments occur where chemicals with a deleterious effect on materials are present. These include, but are not limited to:

- Areas within 2km of the sea shore (saltwater)
- High salinity, high groundwater environments (saltwater)
- Sewage treatment plants (H_2S gas)
- Sewage pump stations (H_2S gas)
- Corrosive chemical storage and dosing areas (various chemicals)
- High humidity, poorly ventilated rooms, chambers, dry wells etc.

Installation within these environments shall be avoided where possible. When elimination of corrosive environments is not possible (e.g. STPs or near the sea), consideration shall be given to the environment, which contaminants are present as well as their severity. Mitigation methods (e.g. selection of materials, coatings, ventilation, air filtering etc.) shall be employed to enable equipment to withstand any corrosive agents identified in the environment for the duration of the equipment's design life.

3.2.3 Flood

Electrical equipment including, switchboards, control panels, generators, transformers and switchrooms shall be positioned away from stormwater flow paths, elevated at least 100 mm above the natural surface level and at least 300 mm above the 1% AEP flood event to prevent inundation causing disfunctions and outages. Where this cannot be achieved, any proposed reduced level of protection will be subject to acceptance by Urban Utilities.

While this specification establishes minimum elevation requirements based on current flood data, users must also consider potential changes in future flood levels due to climate change when determining the appropriate elevation for electrical equipment and other inundation sensitive assets. As per the Urban Utilities' draft Climate Change Adaptation Strategy and Principles (D/23/815604), this includes consideration of the best available projected future 1% AEP flood levels under different climate change scenarios over the expected asset life, plus at least an additional 300mm freeboard as per the current specification. Users must make a best value decision based on the information available, balancing the cost of additional protection measures against the potential consequences of equipment failure during and after flood events. For further guidance

on different climate change scenarios and adaptation options, see the Climate Change Adaptation Manual (draft).

3.2.4 Operating Parameters

Parameter	Value
System voltage (HV)	11 kV ±10%
System voltage (LV)	400/ 230 V +10, -6%
Frequency	50 Hz ± 2%
System earthing	MEN
Control Power	Regulated 24 VDC

Harmonic voltage and current distortion limits at each site shall be as outlined in TEM336 *PSA Guidelines*.

3.2.5 Electromagnetic Interference

Electrical and electronic equipment shall be CE marked and appropriate for use in an industrial environment. The following directives apply to all equipment:

Directive	Applicable Standards	Notes
EMC Directive	EN50081-2 EMC Generic Emission Standard EN50082-2 EMC Generic Immunity Standard	Equipment shall be tested to meet Council Directive 89 / 336 / EEC Electromagnetic Compatibility (EMC) using a technical construction file and the applicable standards
Low Voltage Directive	EN61131-2 Programmable Controllers, Part 2 - Equipment Requirements and Tests	Controllers shall be designed to meet Council Directive 73 / 23 / EEC Low Voltage by application of the applicable standards

3.2.6 Weather and Ingress Protection

Equipment containing wiring or devices that are susceptible to damage or failure due to moisture or dust ingress shall, at minimum, be IP rated or be installed in IP rated enclosures as follows unless otherwise specified:

Location	Rating
Indoors	IP42

Location	Rating
Outdoors	IP56
Outdoors – Areas exposed to flooding	IP67

Outdoor equipment and installations situated in the open shall be suitable for un-protected exposure to the weather, including direct sunlight and hose-down cleaning. Weather hoods and/or sun-shades shall be provided for UV and weather protection.

3.3 Communications Protocols

3.3.1 Preferred Protocols

Devices on the network shall implement the full control stack to ensure reliable, full communication between devices. For all equipment including SCADA, Ethernet is the preferred communications protocol with the following protocols accepted:

- Ethernet/IP
- Modbus TCP
- DNP3
- ProfiNet
- OPC

Ethernet is preferred and RS485 can be accepted for communications between devices located in the same enclosure and both owned/operated by Urban Utilities. Other physical layer connection standards are not accepted unless specified in the Project Documentation or accepted in writing by Urban Utilities.

3.3.2 HV Protection Relay Communications

The IEC 61850 communication protocol shall be provided where communications between IEDs is required for HV equipment protection schemes.

3.3.3 Protocol Converters

Where third-party protocol converters are used, all data-mapping and settings shall be documented in the Functional Specification and other Control System documentation. The converter must be powered from a 24V DC supply common with the PLC and not to be powered from a separate power outlet.

Where PLCs by different OEMs share inter-PLC data, a direct Profinet connection is the preferred method without usage of a third-party module.

Individual RTU/PLC time clocks shall be synchronised with the Urban Utilities SCADA master clock time.

3.4 LAN Configuration

3.4.1 Fibre Ring Topology

Fibre rings shall be installed at STP sites and other complex assets unless specified otherwise in the Project Documentation. The cables shall run in separate paths for all segments of the ring.

Return paths within the same cable way or within the same fibre cable shall be avoided and where required will be subject to risk assessment and Urban Utilities approval.

A minimum of a twelve-core fibre cable shall be installed for fibre optic communication backbones unless specified otherwise in the Project Documentation. Twelve-core fibre cables can be replaced with two parallel six-core cables if required.

STP site control system communication networks shall adopt a self-healing fibre ring topology. The trunk of the fibre ring shall use multimode fibre only. The plant wide ring topology shall consist of managed Layer 3 or Layer 2 with IP routing capability Industrial Network Switches.

Refer to TMS1151 *Preferred Equipment List - Control Systems* for network switch selection.

The use of secure VLANs or dual networks shall be provided. SCADA servers and clients shall share a SCADA VLAN or separate fibre network. PLCs shall be deployed across the second VLAN or second fibre network. The two networks shall be joined via a network router located at each SCADA server or via dual network cards in the server hardware.

Priority for Quality of Service shall be assigned to inter-PLC communications.

3.4.2 Network Monitoring and Security

STP ring networks shall be centrally managed for monitoring and configuration using the supplier's network management software. Network monitoring tools shall be licensed and installed on the EWS for all new STP installations.

Devices shall implement native security features such as central authentication at the device level to prevent unauthorised access.

SCADA LAN within STPs shall not be used for CCTV cameras. The security network shall be segregated from other networks.

3.4.3 Network Capacity

Network capacity for new networks shall be sufficient to ensure a maximum site communications network utilisation of 20%. An estimated network utilisation calculation in the network design shall be provided. Network Calculation tools used shall be detailed within the network design report.

Network traffic loading shall be confirmed during SAT and finalised during the Commissioning phase of the project. The results shall be included within the SAT and Commissioning reports.

3.4.4 Field Instruments and Devices

Refer to TMS1732 *Electrical & Instrumentation General Specification* for detailed requirements for field instruments and devices. Network-connected instruments, devices and drives shall be configured and managed from the EWS where practical.

Field instruments and devices shall interact with the control system via PLCs. Field instruments and devices shall not communicate directly with the SCADA servers. Field device connections to PLCs shall take place via a serial communications link, instrumentation bus or by hardwired signals.

Licenses and gateways for fieldbus instrumentation shall be provided. The license device count shall provide for all installed instruments with an additional 20% spare capacity. Device gateways and software packages such as Fieldcare and Siemens Process Device Manager (PDM) shall be used for remote configuration, backup and monitoring. This software shall be accessible from the EWS. Required software licences and configuration files shall be installed onto the EWS for site backup purposes.

Software and cables for centralised management of drives and motor protection relays shall be provided. The license device count shall be provided for all installed instruments with an additional 20% spare capacity for future expansion.

SIMOCODE ES “Premium” edition shall be provided for use with SIMOCODE drives.

3.4.5 Usage of Wi-Fi

Refer to TMS1151 *Preferred Equipment List – Control Systems* for accepted Wi-Fi Access points.

Use of Wi-Fi in process applications is restricted to use on moving or rotating platforms (i.e. uses that eliminate slip-rings, catenary wiring, tuned-pair radio links or radio-enabled RTUs).

Urban Utilities’ Digital Information team will review all Wi-Fi connections proposed, including technical parameters such as protocols and security layers enabled.

3.4.6 Network Architecture Drawings

New Network Architecture drawings or amendments to existing drawings shall be provided to cover the complete design within the scope of work of the project.

Existing drawings shall be revised using in its native format to cover the scope where network architecture drawings are not available or not up to date. Hand mark-up redlines on an existing drawing are not accepted by Urban Utilities. Electrical or control systems RPEQ certified design drawings shall be submitted.

New drawings and/or updates of existing drawings shall be prepared as required based on site verification tasks and site investigation undertaken as part of the project.

The Network Architecture Drawings shall typically consist of the following details:

Drawing Type	Description
Network Panel Diagram	Control System Panel or Communication panel drawings showing FOBOT and network switch port numbers as well as communication cable connections. Hardware and critical settings shall be shown. All fibre core numbers and cable numbers shall be marked.
Site Network Topology	Drawings displaying devices on the network and their interconnections, including network switches, computers, firewalls, proxies, gateways, fibre backbones/spurs, PLC connections, Wi-Fi connections, WAN connection, HMIs.
Site Layout Drawing	Drawing showing cable routes for fibre optic rings, fibre spurs and fieldbus communications cables, as well as positions of Wi-Fi access points, PLCs, RTUs etc.

Note: IP address information shall not be shown on drawings. IP addresses for all equipment supplied, installed or modified shall be provided in an excel file to Urban Utilities.

3.5 WAN Configuration

3.5.1 Private Radio and LTE Communications

Urban Utilities has an extensive existing private radio telecommunications network. Urban Utilities' private radio network is the preferred communications link for RTU/SCADA sites.

Radio or LTE communication links may be used between component parts of a proprietary control and information system for data gathering, operator commands and supervisory control.

Radio or LTE communication links shall not be relied upon for equipment basic stop/start, reset of faults or for any automatic shutdown functions related to safety systems. These functions shall have a local facility that enables safe autonomous operation.

Two communication options exist within Urban Utilities, with private radio being the preferred link and LTE a viable options if the radio solution is found not to be feasible for the site.

New components and modifications to existing radio networks shall be designed so as to not degrade the current performance and reliability of the existing network. New equipment shall be selected from TMS1151 *Preferred Equipment List – Control Systems*.

For the replacement of “like for like” remote radio sites where the new antenna will be located in the same position as existing, monitored path loss diagnostics may be utilised to provide a suitable radio signal strength.

For new sites or where the new radio antenna cannot be mounted in the same position as the existing antennae, a radio network desktop design must be performed to determine which repeater within the area will provide a suitable communications link. Based on the proposed link, a radio signal site survey shall be performed to confirm the proposed desktop solution.

Designs shall achieve the following:`1

Parameter	Target	Notes
RSSI	≥ -80dB	
Switchboard-mounted antenna pole height (finished ground level)	≤ 6m	Maximum accepted height for a pole mounted on the side of a switchboard
Standalone antenna pole height	≥ (Local Town Plan Building Height Restriction) + 2m	Reduces radio signal interference and loss from nearby tree foliage and/or buildings

A Telstra LTE communications design solution for a site shall only be considered where the Urban Utilities accepted Radio Network Desktop Design Report demonstrates that a private radio network link is not feasible, or if the site requires dual communications links based on site criticality. Based on this determination, a desktop determination if LTE communications to the site is feasible shall be performed utilising the Telstra network coverage map. This shall be followed by a site survey to confirm the Telstra network signal strength.

A LTE site survey shall be performed at each site and whenever a radio signal site survey is performed at the site.

3.5.1.1 Radio Network Desktop Design

When modifying existing radio networks (e.g. via network topology, elevation or change in technology) or proposing new radio networks, a radio network desktop design analysis shall be undertaken. The analysis shall be undertaken using one of the radio network design software packages accepted by Urban Utilities:

- ICS Telecom
- Mentum Planet
- Pathloss

Alternative modelling software may be proposed and must be accepted in writing by Urban Utilities before any design commences.

Prior to radio network design commencing a request shall be submitted to Urban Utilities for the provision of the existing radio network software model. Urban Utilities

will only provide the model(s) where available. Information contained in the model must be verified as part of the design.

A new model shall be generated when an existing model not available from Urban Utilities. The model shall provide GPS co-ordinates, radio type, antenna heights etc and shall allow for all necessary site visits to collect and verify the required data.

The minimum base station data required to be confirmed as part of the design is as follows:

- Transmit power
- Antenna gain
- Antenna model and coverage pattern file
- RF feeder type and length
- Antenna height

In order to get consistent results with the radio path modelling software, only digital terrain databases accepted by Urban Utilities shall be used.

The Radio Network Desktop Design Report shall detail the repeaters within the area, a path profile view and a link detail table with a recommendation table. The engineering calculations showing path loss, cable loss, transmit power, antennae types/gains, length of transmission paths, obstructions, RSSI for different antenna heights etc shall be stated in the report for the proposed radio frequencies.

Urban Utilities will provide the existing Urban Utilities private radio base station locations and frequencies upon formal request. The digital terrain models shall be nominated within the report to understand the level of accuracy for the terrain. Clutter shall be included in the point to point link which can be manually inputted if no clutter data is available.

Urban Utilities must accept the Radio Network Desktop Design Report before the radio signal site survey is commenced.

Urban Utilities will provide TEM596 *Radio Network Desktop Design Report Template.* This is issued for information only.

3.5.1.2 Radio Signal Site Survey

On-site measurements of the radio signal strength shall be taken and the parameters calculated in the Radio Signal Desktop Design Report shall be confirmed. The location of the switchboard containing the radio equipment and antenna location shall have been generally accepted by Urban Utilities before the site survey commences.

Unless subject to environmental controls, trees and foliage that may impact or cause future interference with the radio signal shall be removed. To ensure adequate access to the antenna for inspection and maintenance, proximity to overhead power lines and public roadways shall be considered.

Testing shall be undertaken at a range of antenna heights, above and below the height calculated in the Radio Network Desktop Design Report. If it was found within the desktop design that more than one repeater was available, signal strengths shall be recorded for each repeater.

A Radio Signal Site Survey Report shall be submitted to Urban Utilities for review. The report shall as a minimum nominate the radio frequencies assessed on the site, antennae heights and RSSI recorded at each antennae height. The report shall contain photos of the testing as performed and shall reference the test plan document.

4G signal strength shall be measured using a modem listed in TMS1151 *Control Systems Preferred Equipment List* as specified for the Telstra mobile network. Site measurements shall allow determination of feasibility for a 4G design solution, if required.

Urban Utilities will provide TEM597 *Radio Signal Site Survey Report Template* and is issued for information only.

3.5.1.3 Communications Network Design Report

The Communications Network Design Report is relevant to a private radio and/or a LTE communications solution. The report shall nominate the proposed mast height, the actual antenna mounting height, assess susceptibility to network frequency interference from external noise sources and consider the feasibility of erecting the antenna mast in the proposed location.

Antenna masts shall not be proposed in vicinity of HV transmission lines. Section clearance as per AS2067 must be maintained during installation and while accessing the antenna and mast for maintenance.

Provision for lightning protection of the network components shall be detailed in the design report. Coaxial cable connections to antennas shall have a suitable surge arrestor installed in the switchboard or control system panel.

An options section shall be provided to detail available communication path options, as well as alternative antenna heights, antenna supports/structures and radio link signal strengths for each option. The report shall recommend the preferred solution. The report and recommendation must be accepted by Urban Utilities before finalisation of design drawings and procurement of radio equipment.

A final signal survey shall be undertaken during site commissioning. This survey data shall be used to update the Communications Network Design Report to As Built status. The radio software model shall also be updated and provided to Urban Utilities with the As Built documentation for the site. The radio network software model filenames and versions shall be nominated in the report.

Urban Utilities will provide TEM598 *Communications Network Design Report Template.* This is issued for information only.

3.6 Power Failure Logic

A power outage alarm shall be raised if the utility power supply failure to the site has occurred. Events shall be recorded in the Events log. Alarms for individual items of equipment shall be suppressed if these alarms have been caused by the power outage.

Following the restoration of power, equipment shall restart in a controlled manner. Callouts to operators shall only occur if equipment fails to operate upon restart of the plant.

After power is restored the RTU/PLC shall initialise safely (e.g. with realistic nonzero default settings). The RTU/PLC tag configuration shall ensure that the latest operator adjusted setpoints are retained in non-volatile memory, if different from the default settings, and are maintained following the power restoration.

Control system components including HMI, servers, RTU/PLC racks, remote I/O nodes, instruments, ELV power supplies, network communication devices etc shall be fed from a UPS.

3.7 Design Documentation

3.7.1 Drawings

Required drawings are nominated in the DRL and other Project Documentation. Drawings shall use Urban Utilities standard drawing templates, comply with SEQ Code Asset Information Specification where applicable, comply with PRO307 *Drafting and Drawing Management Guideline for Capital Delivery* and all cross referencing shall use Urban Utilities assigned drawing and document numbers.

Drawings and installation specifications will be provided as listed in the Project Documentation. Drawings and specifications provided by Urban Utilities and not identified as IFC, As Built or issued for use shall not be used unless authorised by Urban Utilities in writing.

Refer to Section 1.4.7 Exceptions for information regarding procedures for proposed deviations from Urban Utilities specifications.

The manufacturer's equipment drawings, installation and operating instructions shall be used where applicable. Any conflict between the Manufacturer's drawings and Urban Utilities supplied drawings and/or specifications shall be referred to Urban Utilities.

3.7.2 RTU/PLC I/O List

The RTU/PLC I/O List shall list the tag allocation per RTU/PLC I/O card. It shall clearly list the RTU/PLC ID, Remote rack ID, Rack location, Card model, rack, slot, point or channel, tag name, equipment description, equipment ON/OFF states, analog range in engineering units, loop and / or RTU/PLC termination drawing.

3.7.3 Control System Part Numbers Lists

Lists PLC, HMI and Network hardware quantities, manufacturer, model/part number, serial numbers, firmware versions and part number release/discontinuation dates. PLC parts shall be grouped by rack and slot numbers to enable ordering of replacements.

3.7.4 Datasheets

Datasheets shall be provided for the following equipment at minimum:

- Control system panels (includes the RTU/PLC processor and I/O modules)
- Communications panels
- Network Switches, Routers, Modems
- Protocol Converters
- SCADA Servers
- PCs
- HMI Terminals

Datasheets shall indicate the Urban Utilities asset tag number and list all pertinent technical data relevant to the equipment.

3.7.5 Alarm List

The Alarm List contains a list of all alarms for the entire control system and must indicate actual text used in each alarm and the tag name of the alarm point. The list must also indicate category of alarm and if alarm is auto reset and all other constraints on where and how the alarms are reset. The Alarm List document is to be included as an appendix to the Functional Specification document. (Payam to add references to FS templates)

3.7.6 SCADA Point List

This document provides a list of data points configured for communications between the RTU/PLC and SCADA as well as all HMI terminals. The document shall indicate tag names and descriptions assigned to every word and bit as well as the data type and upper and lower range for numerical data.

3.7.7 Setpoints List

This document provides a list of all operator adjustable setpoint data applicable to the control system. The list shall be a table comprised of the following;

- Row 1 – Plant Area and plant process or device
- Row 2 – Listing of all available modes of operation to the process or equipment listed
- Mode of Operation
- Setpoint Description

- Tagname
- PLC/RTU address (including Inter-PLC addressing)
- Range
- Units
- Privilege (operator access level)
- Commissioned value

The final commissioned setpoint list shall be included as an appendix to the Functional Specification document.

3.7.8 Process Control Narrative

Project Documentation may call for the development of a Process Control Narrative (PCN) which is also referred to as a Functional Description. The PCN document shall describe the operation of the process for each plant area. This is typically a plain English description but may differ in form and style depending on the process or plant areas being described. This description will not necessarily describe the specific hardware and software being used.

Process calculations shall be included within the PCN.

The PCN shall be reviewed and accepted by Urban Utilities before finalisation of the Functional Specification. The PCN shall complement and align with relevant P&IDs.

The PCN shall be certified by an appropriately registered RPEQ before issue to Urban Utilities for review.

The PCN shall reference and list associated P&IDs, including revision numbers.

3.7.9 Functional Specification

A Functional Specification (FS) shall describe the site-specific control system (i.e. the specific hardware and software environment) including all PLC functionality. The FS shall be derived from and aligned with the PCN. The FS shall be developed in consultation with Urban Utilities stakeholders or third-party stakeholders nominated by Urban Utilities.

The FS shall be accepted by Urban Utilities prior to control system configuration work commencing.

Functional Test results shall not be embedded into the Functional Specification.

The FS shall achieve the following objectives:

- Form a reference document suitable for use by operation and maintenance personnel
    - The FS is not intended to be an operating manual
    - Functional Test results shall not be embedded into the FS

- Provide a plant-wide common 'look and feel' for the functional description for each plant area control system
- Incorporate specific implementation features of the installed equipment
- Provides sufficient detail to program, configure, test and fault-find the PLC software
    - Provide process sequencing requirements
    - Provide the reference point for calculations used
    - Provide a reference listing of alarms, including alarm category, trigger conditions, masking conditions and latched or self-resetting. "Derived" alarms shall be listed in addition to direct alarms.

The following requirements apply to calculations:

- Single instance calculations shall be clearly outlined
- Reused calculations used in subroutines or held within function blocks shall be fully documented as part of the Function Block Library
- PLC/RTU code and comments shall fully reflect the calculations listed in the FS
- Lookup tables used within the PLC/RTU or used by a calculation shall be listed. Information sources and revision of the table shall be clearly referenced.

Control loop diagrams shall display:

- Limits and setpoint clamping
- PID manual and auto control signals
- Sources of setpoints and mode selections
- Tag names and calculations may be included within the blocks where spacing allows.

Process automation sequencing requirements shall be detailed, including:

- A high-level description of the sequence operation, including steps and transitions. A Flowchart shall supplement the description.
- Description of sequence implementation methods and specific function blocks or tools used (eg. SFC, FBDs, ladder)
- Description of SCADA visualisation and sequence control including all steps, transitions, interlocks, permissives, timers, conditions. Sequence step numbers shall be trended for diagnostics purposes.
- List of operator inputs and action required inclusive of setpoints (e.g. operator-initiated sequence pauses, alerts to indicate operator input is required)
- Lists of Sequence Start permissives
- Lists of Sequence Run permissives
- Descriptions of step-transition triggers, permissives, actions and confirmation of successful transition for each step. Bi-directional sequencing (e.g. blower control), shall include both up and down transitions.
- List Failure modes
    - Rapid Shutdown mode - for emergency scenarios
    - Return to step X mode - to minimise wastage
    - Power outage restart

    - Operator reset requirements
    - Ensure the sequence step is re-initialised to the correct step and all equipment is ready to return to service
- List methods used to detect a sequence failure (e.g. watchdog timeouts, high alarms)
    - Detect a failure during the running sequence
    - Detect a failure during the sequence start or transition
    - Detect a failure within the Shutdown sequence
    - Detect a failure due to a power outage

The following composition requirements apply:

- Uses past and/or present tense (i.e. “As Built”). Future tense will not be accepted.
- The FS shall contain no company branding other than Urban Utilities, including logos, icons, headers footers and borders
- Externally generated or updated FSs shall state full author name and company details within the revision control table
- Sections and sub-sections in the FS shall be clearly numbered and logically defined so all functionality may be unambiguously referenced by ITPs
- Where applicable, proposed amendments to be provided by others at post-handover (eg. proposed future change to PID tuning parameters) shall be provided
- Cascading or complex PID control loops shall be graphically represented using Microsoft Office Visio and inserted into the FS
    - Small control loop diagrams may be shown in the document body whereas larger diagrams shall be attached as an appendix
- File formats provided at handover shall include:
    - Signed PDF file incorporating all elements and appendices
    - Native Microsoft Word file
    - Native Visio files
    - Other native files as applicable

Refer to the table below for a list of typical functional specification templates, providing examples of the level of detail required for each application:

Site Description	Template Type	Template
Complex Sites (e.g. RRCs, SP010 Eagle Farm)	Standard	TEM514
Sewage Pump Station	Site Specific	TEM515
	Standard	TMS1650
Reservoir Site	Site Specific	TEM593
	Standard	TMS828
PRV Site	Site Specific	TEM588

Site Description	Template Type	Template
	Standard	TMS200
Water Pump Station	Site Specific	TEM592
	Standard	TMS1706
Vacuum Pump Station	Standard	TMS1631
Water Booster (Lowara)	Site Specific	TEM590
Water Booster (MPC)	Site Specific	TEM587
Water Booster (MPC)	Standard	TMS1649
Water Booster (VSD)	Site Specific	TEM591
Water Booster (VSD)	Standard	TMS1643

3.7.10 Software Design Specification

The Software Design Specification (SDS) is the next level of detail from the FS and is provided to assist control system engineers and others to understand how to navigate the RTU/PLC software and SCADA configuration settings. It is required to enable fault finding in RTU/PLC and SCADA systems, software simulation bench tests, FAT, SAT, commissioning and reviews of RTU/PLC code for compliance with Urban Utilities standards.

The SDS includes control system programming philosophy, program structure, point naming conventions, use of global variables versus local variable, constants, initialisation processes, layers of abstraction, objects, devices, sequencing, interlocks, communications interfaces etc. The SDS shall detail the RTU/PLC code configuration, describe software structure and demonstrate compliance with Urban Utilities standards. Selected code backup examples may be provided by Urban Utilities for consistency between sites. The site-specific structure shall be followed for brownfield sites. Request for functional improvements may be made through the RFI process. Requests for deviation shall be made as per PRO752 *Deviation from Technical Standards.*

For small projects the SDS and FS may be submitted as a combined document. The documents shall be provided in separate documents unless specified otherwise in the Project Documentation.

3.7.11 Software Test Strategy

A Software Test Strategy shall be provided unless specified otherwise in the Project Documentation.

The Software Test Strategy entails a description and engineering analysis as to the basis of the testing proposed, and the manner in which acceptance testing will be completed

and verified as completed. This typically needs to link to elements of the Software Design Specification.

The full suite of acceptance testing shall be traceable to the Functional Specification and Software Design Specification.

The software test strategy shall specify how defects and modifications are tracked along with appropriate regression testing and adjustments to specifications and test documents to support the modifications. The test strategy shall define the level of re-testing and/or regression required based on various factors including design and functionality changes, standard code changes, standard object changes, defects discovered, modifications made to date, etc.

Regression Testing shall be used to verify all modifications made to tested or standard code have not detrimentally affected the performance of the tested or standard code. The basis for the decision as to the extent of regression testing shall be supported by documentation and a combination of programming software version, source code versions, hardware versions, firmware versions, specification versions, acceptance testing records and versions, change records, history in production, existing functionality, existing configurations, object testing, capacity assessments for licenses, communications, server resources, PLC or RTU resources.

PLC and RTU resources include elements that have a limited capacity including I/O, CPU processing, internal memory, external memory, racks, ports, etc. The capacity assessment shall ensure specified spare capacity shall be maintained.

The software test strategy shall satisfy all of the following criteria:

- Object Testing – Discrete software object testing; inclusive of function blocks, device testing, subroutines.
- Component Inspection and Testing – software inspection and testing, modelling and simulation, system integration bench testing of components.
    - This includes simulation software function blocks, methods of simulation, integration of the new objects into existing site standards and libraries, compilations warnings, diagnostics errors
- System Integration - Subsystem/Configuration item qualification, modelling and simulation and system integration bench testing, verify specification requirements
    - The system integration testing strategy shall list for each instance of standard code and standard object:
        - the versions
        - the Functional Specification
        - the Software Design Specification
        - the interfacing of the standard software component
        - the specific interactions with other objects, code and within the overall solution.
    - Loading analysis with the additional objects introduced into the system – e.g. additional communications loading, sufficient licensing points, hard disk capacity, CPU processing capacity,

- System Verification – verify the integrated system meets the system specifications.
    - All system failure modes have been covered, such as power failure and recovery, communications redundancy, PLC and I/O redundancy, black starts, setpoint retention, remote access, network failure and recovery, network flooding, PLC/RTU resets, I/O states in failure modes, server redundancy, protocol gateway failures, instrument failures, etc.
    - Testing of System Performance criteria
    - Tests to assure compliance with industrial control systems security requirements
- Process and Operations Performance Validation – Test and evaluation of process operational requirements, validating solution performance against the process control narrative and functional specification

3.7.12 Cause and Effects Charts

Project Documentation may call for the development of Cause and Effect Charts. These are complimentary to the control system Functional Specification document and shall concisely document the operation and interlocks of the process control system.

3.7.13 HMI User Manuals

Separate HMI User Manuals for all SCADA Client Workstations and local HMI terminals installed in process areas or switchrooms shall be prepared. Manuals include screenshots of each HMI screen and popup window, providing detailed descriptions of all control and monitoring features at each. Manuals cover user interface facilities, screen navigation, login privileges, alarm management, reporting, trends, sequences, user setpoint windows, custom devices, pop-ups and site-specific features.

Manuals shall be used to undertake testing of the HMI screens. Urban Utilities will not witness testing of HMI screens until the HMI User Manuals have been accepted.

For smaller projects such as pump stations the HMI User Manual maybe combined into a common document with the FS. The HMI User Manual and FS shall be provided separately unless specified otherwise in the Project Documentation. For STPs there shall be a separate site-specific SCADA User Manual and a local HMI (Redlion) User Manual.

For SPRI inlet pump stations within an STP, the site-specific SCADA user manual shall detail the pump station statuses, alarms, setpoints and controls.

3.7.14 PLC and SCADA Function Block Library Specification

A separate document or additions to existing Urban Utilities documents shall be provided detailing all new function blocks created as part of the works (refer to

Section 5.5.4 for Library use). At minimum, this shall contain the full functional specification for the block including but not limited to:

- Revision control (full name of the programmer, company, date, revision and comments)
- Minimum system requirements including
    - PLC platform including programming software version, patches, service packs,
    - Minimum CPU firmware version
    - Other dependencies such as other function blocks, subroutines
- The functionality and purpose of the function block
    - All modes of operation
    - Function block interfaces and data structures shall be itemised and described in detail, including;
        - Itemised description of each data structure row (including spares)
        - Each Pin's operation and purpose
        - Register address
        - Tagname suffix list & descriptions (eg. aiVolts, aiFlow, diFault)
        - Data types and length
        - Initial values
        - Engineering Units
        - Scaling parameters
        - Retentive or non-retentive
        - Filtered or non-filtered
    - Pin naming conventions for different uses (e.g. setpoints, alarm, status, interlock, permissive, operator command, output etc.) shall be described meaningfully
    - Pin naming convention shall reflect the ON state of the pin eg. pin 'dsFault' = ON when fault is active
    - Describe ON and OFF states for digitals
    - Analog limits
- The Pin is defined as the input and output connection points of the function block
- Internal calculations, derived alarms, latched signals, sequencing, statistics etc. contained inside the function block shall be detailed in the document. The detail shall allow implementation of the block to be easily understood without reading the code.
- Screen shots of all SCADA interface templates shall be included directly following the function block's description. The SCADA template description shall detail all colour codes, symbols, run, stop, open, close, fault, alarm states. There shall be no ambiguity as to operator entry requirements, limits or implementation.
- All code, function calls and system dependencies required to implement and operate the SCADA template shall be fully documented including version control.

4 HARDWARE

4.1 General

4.1.1 Device Ruggedness

Electronic devices shall be rugged, hardened against corrosion and suitable for industrial applications. Oversizing, sparing, redundancy and replacement strategies and their effects on whole-of-life costs shall be considered when selecting equipment.

Electronic devices for process control, monitoring safety or communications installed within or in proximity to corrosive environments (e.g. RRCs and SPSs) shall be manufactured with tinned copper conductors and conformal polyurethane based coating (or other equivalent harsh environment coating) applied to circuit boards. Dismantling of OEM devices by third parties in order to apply conformal coating or to retrofit tinned copper conductors shall be avoided.

Control system panel wiring shall be tinned in SPSs and RRCs.

4.2 PLC Hardware

Refer to TMS1151 *Preferred Equipment – Control Systems* for PLC and RTU hardware.

There shall be a minimum of 20% spare installed I/O of each card type and at least 20% spare unused slots in PLC racks for future expansion of the I/O count. In the case where multiple PLCs or remote racks are distributed across the functional areas of the plant, then each functional area shall provide 20% spare I/O capacity.

There shall be a minimum 20% spare processing capacity following commissioning for new PLCs. Spare memory capacity (including removable memory cards) shall be 40% to allow the future addition of working memory, non-volatile variables, timers and counters.

For existing sites, new PLC hardware selection should be consistent with whichever manufacturer predominates at that site.

4.3 Control System Panels

Enclosures covered by this section shall have the following characteristics:

- ELV supply or LV supply with internal ELV conversion
- Primarily or exclusively used for control, communications or field instrumentation
- Supplies no outgoing LV power circuits

Enclosures used for power distribution, including switchboards and distribution boards with internal control and communication components, are covered by TMS60 *Low Voltage Switchboards*. Enclosures for power distribution and control provided with

Packaged Plant are covered by TMS1645 Packaged Plant – *Electrical, Instrumentation & Control Systems*.

4.3.1 Ventilation

Internal cooling of equipment enclosures shall be by natural or forced air ventilation.

Equipment prone to overtemperature failures (e.g. UPS) or employing forced ventilation shall have enclosure temperature monitored by a thermostat, with an overtemperature warning alarm and shutdown alarm provided.

Custom, non-type-tested enclosures, or those intended for environments exceeding type test conditions (e.g. outdoor installation), shall have a ventilation cooling design calculation completed before manufacture commences. The calculation shall demonstrate that the maximum internal temperature will not exceed the temperature rating of any internal component.

The cooling design calculation shall consider worst case specified ambient temperature and component heat dissipation.

In order of preference, ventilation methods for these enclosures shall be as follows:

1. Natural ventilation
2. Forced ventilation, with N+1 redundant fans

Air intake and exhaust outlets shall be provided with removable SS316 mesh screen. Where vent hoods are required to achieve the specified IP rating, they shall be of the same material and finish as the enclosure. When air filters are recommended by the manufacturer or outlined in Project Documentation, these shall be provided on air intake and exhaust outlets. Filters shall be removable for cleaning. Screens and vents must be removable from inside the enclosure without need to unbolt the gear tray or remove equipment from the gear tray to gain access.

4.3.2 Control System Panel Construction

Control system panel construction shall be as follows:

Parameter	Indoor Panel	Outdoor Panel
Minimum IP Rating	IP44	IP56
Form of Separation	Form 1	Form 1
Minimum Material Grade & Thickness	1.6mm Zinc-plated steel	2.5mm marine grade aluminium
Fasteners	Zinc-plated mild steel	Stainless steel
Spare space	20% for future equipment, terminals, gland plate holes	

4.3.2.1 Enclosures

Control system panels shall be completely self-supporting fully welded rigid structures.

Equipment gear trays shall be rated for the load and supported by studs welded to the case.

Heavy equipment shall be supported by separate independent framework and shall not rely on the enclosure sheeting.

Equipment shall be removable via the front access doors.

Control system panels located in outdoor locations exposed to the weather shall be provided with a sloped rain hood. Control system panels containing active components shall be provided with sun shades.

4.3.2.2 Doors, Locks and Handles

At least one document holder shall be provided inside each control system panel's front door.

Closetrade - Swing Handle HW-HAND-FLUSH-SS-MS874 with Closetrade - 3 point lock rod set HW-CAM-3PL-SET-3B4500-RG006-1-316SS shall be installed.

Lockwood Barrel Locks are to be fitted with Key Codes RC496A, RC496AB, RC496ABC. Contact Urban Utilities for clarification as to where each is required.

Lockable 'T' handles shall be keyed L & F 92268.

4.3.2.3 Paint Treatment

Control system panels shall have coatings inside and out as per manufacturer recommendations and suitable for the application. Paint colours for control system panels shall be as follows:

Location	Internal Surfaces	External Surfaces	Gear Trays & Escutcheon
Indoors	RAL7035 to AS 2700	RAL7035 to AS 2700	Gloss White
Outdoors	Dulux Mist Green (36648), matte finish	Dulux Mist Green (36648), matte finish	Dulux Bright White (32166)

4.3.3 Cabling, Wiring and Equipment General Arrangement

Equipment in the control system panel shall be arranged to allow adequate space for the installation and termination of internal and external wiring. There shall be a suitable amount of space between the internal components to allow easy access for maintenance on the equipment, including the removal of failed equipment without the need to disassemble adjacent equipment.

Cabling and wiring shall be accessible. All wiring shall be one continuous length from terminal to terminal. Splicing, jointing or teeing shall not be permitted.

Common wiring between compartments (i.e. 24V DC, 0V etc) shall be configured such that removal of a wire (or loose wiring) within one compartment shall not cause loss of connection to other compartments.

Electronic protection equipment requiring connections to AC supply, current transformers, voltage transformers, baluns and the like shall wherever possible be directly connected to such equipment.

A minimum 50mm shall be maintained between each terminal row and any cable ducts to provide sufficient clearance for fanning of conductors for termination and for affixing ferrules for wire identification.

Equipment shall be mounted on a gear tray and not directly to the external metalwork of the enclosure in such a manner so that all equipment can be removed without unbolting the gear tray. Self-tapping screws for fixing equipment to gear trays is not accepted.

All terminals types shall be mounted on DIN rails that are attached to a gear tray, with the open side of the terminals facing upwards.

DIN rails shall be single, continuous lengths extending the full length between wiring ducts.

Outgoing power wiring shall be arranged to allow the use of a clip-on ammeter for testing purposes.

Where practical, all field cables shall be terminated on the same side of the terminal blocks within an enclosure.

Terminal strips shall be mounted vertically to facilitate ease of cable termination and identification of terminals.

Terminals for the connection of field cables shall be located as close as practical to the point of entry of the cable into the enclosure. Where possible, terminals shall be located to prevent field cables (or cores part of) being routed through a compartment for termination into another compartment.

Cabling and wiring between compartments shall be routed through suitably sized holes cleanly punched in the metalwork and protected with grommets or similar to prevent insulation damage.

Cables shall not be bent at less than the minimum bending radius recommended by the cable manufacturer.

4.3.4 Cable and Wiring Containment

Cabling and wiring within the enclosures shall be neat, firmly secured and enclosed within PVC cable ducts. Wiring looms or spiral wraps shall not be permitted except for wiring connections to hinged equipment (doors etc). Cable ties shall be installed with a manufacturer-recommended tensioning and cutting tool.

Where ducts are mounted upside down, the wiring shall be cable tied/supported to prevent the duct lid being forced open by the weight of wiring upon it.

Ensure minimum clearance of 100mm is maintained between cable ducting and gland plates.

The use of terminations as the only means of wiring support is not permitted.

Self-adhesive wiring supports shall not be used.

Cable ducts shall be side slotted PVC and shall have positive continuous (or clamping) edges on both the wiring channel and the cover.

PVC ducts shall be sized such that their cross-sectional area utilisation factor does not exceed 60% when newly installed.

4.3.5 Segregation and Shrouding

Within enclosures segregation of cabling and wiring shall be achieved through either physical distance or separate slotted PVC cable ducts.

Wiring shall be grouped by susceptibility levels and these groups shall be segregated from each other:

Level	Susceptibility	Cable Types
1	High	Intrinsically Safe instrumentation (analog & digital) Intrinsically Safe Fire & Gas
2	Medium	Non-Intrinsically Safe instrumentation (analog & digital) Non-Intrinsically Safe Fire & Gas ELV power & control (≤50V DC / ≤120V AC) Telecommunication (Ethernet, Modbus, Fieldbus, telephony etc.)
3A	Low	LV power ≤20A LV control

In addition to the above, intrinsically safe wiring and safe area wiring shall be segregated in different ducts

Refer to TMS1732 *Electrical & Instrumentation General Specification* for cable segregation requirements for field cables.

Where the control system panel is fed from an LV supply, the main isolator for the panel shall be shrouded and segregated from ELV components. Terminals with circuits operating above ELV shall be segregated using removable shrouding that fully surrounds the terminals.

The shrouds shall be a clear transparent insulating plastic with a fully visible red/white/red warning label. Warning labels on shrouds shall contain the text “Danger XXX Voltage”, where XXX is the maximum voltage level behind the shroud.

Different voltage levels on banks of contacts of individual devices shall be avoided where practical

Cable entries shall be grouped by voltage level where practical.

Protection against contact with live parts at greater than ELV shall be at least IP2X.

4.3.6 Door and Escutcheon Wiring

Flexible wiring shall be provided to equipment mounted on doors, escutcheons or similar hinged moving equipment. The wiring loom shall be clamped to retain the loom in position and to prevent any strain or rubbing of the wiring for the full travel of the door or escutcheon.

Spiral wrap, split tubing or similar shall be installed to provide mechanical protection for door and escutcheon wiring looms.

New wiring and new equipment operating at voltage levels exceeding ELV shall not be installed on existing control system panel doors or escutcheons.

4.3.7 Transportable Sections

Where equipment is required to be split for transport, the internal wiring between transport sections shall terminate at a row of dedicated marked terminals located on one side of the break.

The disconnected wiring between transport units shall be crimped (with termination pins/lugs), loomed together and clearly marked for easy identification and on-site connection into the terminal blocks located in the adjacent transport unit.

4.3.8 Earthing

Control system panel earth bars shall meet the following requirements:

- The earth bar shall be provided with suitable termination facilities for the connection of the earth conductors on incoming and outgoing cables and these shall be provided in each terminating zone
- The earth bar shall be colour-coded with green/yellow bands at maximum 300 mm intervals

- The earth bar shall be tapped and fitted with bolts, washers and spring washers to accommodate the earth connections for all incoming and outgoing cables.
- Connections to the earth bar shall be secured with two screws.

Control system panel components requiring earthing shall be bonded to the control system panel earth bar. These include:

- Metal parts of the enclosure
- Secondaries of current transformers shall have one lead earthed
- Metal cases of instruments, relays, selector switches, etc.

Earthing connections shall be arranged so that removal of one component will not affect continuity of the earthing conductor associated with any other component.

Doors and escutcheons fitted with control and/or indicating equipment shall have an independent flexible earth strap with mounting bolt and nut, or stud welded to the door.

An isolated instrument earth bar with 20% spare capacity shall be provided in the PLC marshalling terminal section. The instrument earth bar shall be bonded to the main earth bar with a single 4mm^2 G/Y PVC cable.

4.3.9 Miniature Circuit Breakers

The supply voltage level for control system panels shall be 24VDC unless specified otherwise in Project Documentation.

Where a control system panel is fed from an LV supply, the upstream LV protective device shall include a 30mA RCD. RCDs shall not be installed on the line side of UPSs.

Where the LV supply is not fed from an UPS, a surge protection device shall be installed at the control system panel. The surge diverter shall be fuse protected, rated for 50kA (8/20 µs), offer bi-directional protection and be current rated for the connected load.

Power supply feed cabling shall be connected to a main circuit breaker or main isolator prior to connection with any electrical equipment. The circuit breakers (and/or terminals if required) shall be close to the cable entry point to alleviate the need for running the cable through the cabinet.

MCBs shall be equipped with both overcurrent and instantaneous trip protection.

Single-phase AC or DC main MCBs shall be two-pole unless specified for the application in Project Documentation.

The main CB or isolator's status and operating facility shall be visible and accessible from the front of the panel. MCBs shall be equipped with clear labelling to indicate whether they are ON or OFF.

Main MCBs and main isolators shall be individually padlockable in the off position. This facility shall be an off-the-shelf arrangement suitable for standard scissor locks/hasps allowing group isolation.

MCBs shall be mounted on rails attached to the gear tray. Distribution for each voltage level shall be in a common area of the control system panel. Different voltage level distribution sections shall be segregated from each other.

Where more than one wire is to be connected to one side of an MCB for looping purposes to adjacent MCBs, preformed proprietary link bars or combs shall be provided.

MCBs and isolators shall incorporate captive terminal screws and metal lock dogs.

A typed legend in a plastic clear folder shall be provided for all levels of voltage distribution in the panel and fixed to the inside of the control system panel front door.

4.3.10 Control, Tripping and Auxiliary Power Supplies

Unless specified elsewhere, the control, tripping and spring charging supply for circuit breakers and latched contactors shall be 24V DC supplied from an external battery and charger unit independent of the control system DC power supply. A separate circuit for each function shall be supplied.

4.3.11 Actuators, Pushbuttons and Control Switches

The functional requirements of all actuators, push buttons and control switches shall be defined on the relevant project drawings. Actuators, pushbuttons and control switches shall be heavy duty, oil tight and fully rated for the operating conditions and specific application. The device and method of installation shall be selected to maintain the IP rating of the enclosure. Devices shall be selected from TMS62 *Preferred Equipment List - Electrical and Instrumentation*.

Push-button switches, except emergency stop pushbuttons shall have a full shroud to prevent inadvertent operation. Emergency stop pushbuttons shall be of the mushroom head, latched type, manually reset and coloured red. Emergency stop pushbuttons shall have a guard rings rather than full shrouds.

4.3.12 Emergency Stop Circuits

Emergency Stop circuits shall be Category 2 in accordance with AS/NZS 4024. This may be reduced by risk assessment (see Section 1.4.4.1 Machine Safety). An RPEQ-certified design report shall validate the reduction in Category.

Emergency Stop circuits for dry well and wet well submersible pumps have been risk assessed and are accepted as Category 1. Further risk assessment and design reports for Category 1 Emergency stop circuits are not required on pump station sites.

4.3.13 PLC

Refer to Section 2.2 PLC Hardware.

PLC spare I/O shall be terminated to marshalling terminals.

Field cables are terminated to marshalling terminals in the control system panel before connecting to the PLC I/O cards.

4.3.14 Batteries

Battery cells shall be Lithium Ion Phosphate or VRLA batteries for RTU and PLC backup power supply. The cells shall be connected in parallel strings so any individual cell failure does not render the entire battery bank unavailable. Required battery backup time shall be determined based on criticality as defined in Project Documentation. The battery sizing calculation shall be based on the maximum demand of the DC power system as well as a derating for maximum ambient temperature inside the battery enclosure. The AmpHr rating calculated shall be the battery end of design life AmpHr rating.

Batteries shall be suitable for 10-year design life at the installed conditions.

Battery compartments in control system panels shall be naturally ventilated and segregated from other compartments in the panel. Where Lithium Ion battery cells are provided the battery compartment shall have physical space to accommodate VRLA battery cells of the equivalent AmpHr rating, in the future if required.

Battery cells shall be individually date stamped at the date they were installed.

4.3.15 Surge Barriers

Field cables shall connect directly to surge barrier terminals.

Surge barriers shall be selected as per TMS62 *Preferred Equipment List – Electrical and Instrumentation*.

4.3.16 Intrinsically Safe Barriers

Refer to TMS1733 Electrical General Specification for intrinsically safe equipment.

4.3.17 Ethernet Switches

Ethernet switches shall be selected from TMS1151 *Preferred Equipment List – Control Systems*.

Ethernet switches shall include 25% spare copper port(s) capacity. If the switches contain fibre port(s), then 25% spare or one (1) spare fibre port shall be provided whichever is greater.

4.3.18 Media and Protocol Converters

Media and protocol converters shall not be used without written approval. Note the following:

Converter Type	Notes
Serial to Ethernet	Equipment interfacing with SCADA shall have inbuilt Ethernet connectivity
Copper to Fibre	Equipment communicating via FO shall have inbuilt FO ports
Protocol	Appropriate topology and common protocols shall obviate the need for protocol converters

4.3.19 Fibre Optic Break Out Trays (FOBOT)

FOBOTs shall be selected from TMS1151 *Preferred Equipment List – Control Systems*.

Spare capacity requirements for FOBOTs are as follows:

- FOBOTS shall have 50% spare unused ports provided for future cable termination
- FOBOTs forming part of the communication backbone shall be sized to allow a future additional cable of equal size to be terminated

Construction requirements for FOBOTs are as follows:

- FOBOTs in communications panels shall be rack mounted
- FOBOTS in control system panels shall be DIN rail mounted (i.e. compact)
- FOBOTs shall be rodent proof with all holes securely sealed

Termination requirements are as follows:

- New FOBOTs and patch panels shall use SC type connectors
    - Connectors into existing FOBOTs shall be the same type as currently installed
- Spare cores shall be terminated and identified
- Unused ports shall be capped at the FOBOT to prevent the ingress of dust

FOBOTs shall meet the following requirements for cable management:

- Patch leads shall not bend excessively when closing FOBOT access doors, enclosure doors or removable side/rear panels of enclosures.
- Cable management facilities shall be provided for patch leads
- Fusion splice joins shall be housed within splice cartridges within the FOBOT
- Fibre optic cable entering FOBOTs shall be appropriately supported and restrained. The weight of the cable shall not be supported by the FOBOT enclosure.

FOBOTs shall be located as follows:

- FOBOTs shall be installed in readily accessible locations. Installation inside lighting poles or other restricted access areas is not accepted.
- FOBOTs shall be mounted as close to the top of enclosures as practical

The following labelling requirements apply:

- FOBOTs shall be assigned unique equipment tag numbers as per TMS1647 *Plant and Equipment Tag Numbering* and visibly labelled with a traffolyte label.
- A label "WARNING: FIBRE OPTIC CABLE" with black text on a yellow background shall be prominently affixed to each FOBOT
    - This may be a sticker when the FOBOT is inside a control or communications panel
    - Otherwise, labels shall be laminated traffolyte with slotted holes, attached to the equipment where appropriate via stainless stainless-steel screws or bolts

4.4 Communication Panels

Unless specified otherwise in Project Documentation, communications equipment in switchrooms at large sites (e.g. STPs) shall be mounted in communications panels as follows:

- Standalone, Rack Unit Type
- Size: 42RU
- Front and rear accessible
- Barrel locks as per Section 2.3.2.2 Doors, Locks and Handles
- Wall-mounted or floor-mounted on a galvanised steel plinth
- Panel shall contain only communications equipment and cabling
- Communication cable access to the panel shall be individually glanded
- Supply voltage level shall be 24V DC
- Supply shall be UPS-backed
- Installed indoors only

New communications equipment installed at Network Assets or located in the field (e.g. STP process areas) may be integrated into a PLC control system panel or switchboard compartment.

The requirements for internal equipment outlined in Section 2.3 Control System Panels shall apply to equipment installed in communication panels.

4.5 SCADA Servers

Where any Operational Technology server / workstation hardware or software is required, please refer to the Urban Utilities, Digital & Information, OT Team for supply details. Contact operational.technology@urbanutilities.com.au

4.5.1 Local HMI Terminals

Refer TMS1151 *Preferred Equipment List – Control Systems* for local HMI terminal requirements.

Appropriate use of HMI terminals includes:

- Control and monitoring of switchgear
- Control and monitoring of network assets where the SCADA server is remote from the site
- HMI included in OEM packaged plant. Functionality of vendor proprietary systems shall be replicated on the Urban Utilities SCADA system

A local HMI terminal shall not be used as a substitute where a SCADA Client workstation is required.

Operation of the control system shall not be compromised by a failure of a local HMI. Local HMI statuses, alarms, fault codes, setpoint entry and operator commands shall be duplicated on the Urban Utilities SCADA system.

4.5.2 SCADA Client Workstations

Where any Operational Technology server / workstation hardware or software is required, please refer to the Urban Utilities, Digital & Information, OT Team for supply details. Contact operational.technology@urbanutilities.com.au

4.5.3 Engineering Workstations

Where any Operational Technology server / workstation hardware or software is required, please refer to the Urban Utilities, Digital & Information, OT Team for supply details. Contact operational.technology@urbanutilities.com.au

4.6 Cables & Wiring

Field cables, including cable management systems and glands, shall be selected and installed in accordance to the relevant sections of TMS1732 *Electrical & Instrumentation General Specification* and Project Documentation.

Plugs and cables supplied with standard equipment items shall not be modified and shall be installed as per the manufacture's recommendation.

Refer TMS1151 *Preferred Equipment List – Control Systems* for copper and fibre optic communications cables accepted by Urban Utilities.

4.6.1 Wire Insulation Colour Coding

Insulation colours for wiring shall be as detailed in the following table and in accordance with AS/NZS 3000:

Description	Colour
400 V AC Power Wiring	Red, White, Dark Blue
Potential Metering (240/415 V AC)	Red, White, Dark Blue, Black
Current Metering (Secondary)	Red, White, Dark Blue, Grey
230 V AC Active	Red
230 V AC Neutral	Black
24 V DC Battery bank main flexible cable positive supply	Red
24 V DC battery bank main flexible cable negative supply	Black
12 or 24 V AC or DC Positive Supply to Distribution Terminals or Fuses up to the first point where the circuit activates a contact or device.	Orange
12 or 24 V AC or DC after the first point where the circuit activates a contact or device.	Grey
12 or 24 V AC Neutral or DC Negative Supply to Distribution Terminals or Fuses and to negative connections on devices	Violet
PLC, RTU & General 24 V AC & DC after Distribution Terminals or Fuses. Both Positive & Negative	Grey
Electrodes	Salmon
Intrinsically Safe (external sheath)	Light Blue
Earth	Green/Yellow
Instrumentation, 4-20mA (+)	White (twisted pair)
Instrumentation, 4-20mA (-)	Black (twisted pair)
Instrumentation, Triad – 3rd Core	Red
Electrode Wiring	Salmon
Intrinsically Safe Wiring	Light Blue

Note: 110VAC, 110VDC and 48VDC voltage level circuits are not generally accepted by Urban Utilities. Equipment and circuits operating at these voltage levels shall only be installed where indicated on Project Documentation.

4.6.2 Cable and Wire Conductor Sizing

Application	Location	Minimum Conductor Size	Notes
Instrumentation	Field	1.5mm^2	Twisted pair cable with individual screens and overall screen (single pair screened also accepted)
Instrumentation	Internal to enclosures	1.0mm^2	Single core
Control	Field	1.5mm^2	Single core
Control	Internal to enclosures	0.5mm^2	Single core

Application	Location	Minimum Conductor Size	Notes
Power (400V AC)	All	2.5mm^2	Single core
Power (230V AC)	Field	2.5mm^2	Single core
Power (230V AC)	Internal to enclosures	1.5mm^2	Single core
Power (ELV)	Internal to enclosures	1.0mm^2	Single core
Electrodes	Internal to enclosures	1.0mm^2	Single core
Potential / Current Metering	All	1.5mm^2	Sized against the related circuit breaker burden
Earth Cables	All	2.5mm^2	Single core, including equipotential bonding
Door & Escutcheon Earth Bonds	Internal to enclosures	4.0mm^2	Single core
High Density I/O	Internal to enclosures	0.5mm^2	Multi-pair, within enclosures after distribution terminals or fuses only
Telecommunications	All	0.4mm^2 (22AWG)	

4.6.3 Cable and Wire Terminations

Conductors in control system panels shall be terminated using pre-insulated ferrules as per the following table:

Terminal Type	Ferrule Type
Tunnel	Bootlace
Stud	Ring
Other Screw-In Terminals	Fork / Spade preferred

The following requirements apply to ferrules and lugs for terminal connections:

- Lugs and ferrules shall be crimped using a ratchet crimping tool (Grafoplast YAC-5 or accepted equivalent) prior to insertion into the terminal
- Crimping shall not be effected using the terminal screw alone
- Flat and spring washers or similar accepted locking devices shall be used on all stud terminations
- Not more than two wires shall be terminated on any one stud type terminal
- Not more than one wire shall be terminated in any tunnel type terminal
    - Where multiple connections are required on tunnel terminals, multiple terminals linked with proprietary terminal link bars shall be used.
- Pre-insulated ferrules and lugs shall not be used to terminate conductors where a suitable terminal is not provided for that purpose. Under no circumstances shall earth bar connections, equipotential bonds, conductors exposed to the

environment or conductors likely to undergo movement be terminated using pre-insulated ferrules or lugs

The following requirements apply to terminals:

- Terminals shall be rail mounted, clip-in, tunnel type or spring clamp terminal type, and shall incorporate vibration resistant, captive pressure screws which shall not bear directly on the wire.
- Knife gate marshalling terminals with minimum size for 2.5mm^2 conductors shall be installed for all control and instrument field cable cores
- All I/O wiring shall contain fuse(s) to protect the card and individual channels of the card. Where fuse terminals are provided aa minimum 10 off spare unused fuses shall be provided inside the panel.
- Terminals shall be suitable for copper conductors
- Terminals shall be rated minimum 600V
- Terminal block insulation shall be of a non-grid, non-hygroscopic, non-tracking, non-flammable material
- Terminal shall have minimum ingress protection rating of IP2X to prevent accidental contact during inspection and maintenance
- Terminals shall be sized to suit the conductor size and current rating (minimum of 2.5mm^2 conductor)
- Terminals with hinged components, such as fuse and disconnect terminals, shall be hinged on the right-hand side unless advised otherwise
- Single level test/disconnect terminals shall be used for marshalling analogue I/O wiring
- Dual level terminals may only be used for marshalling digital I/O wiring in existing control panels where spare space is limited. The upper level terminals shall be odd numbered and the lower level terminals shall be even numbered. Multiple level or tiered terminals shall not be used for other applications including new control panels unless accepted by Urban Utilities in writing
- Push-in clamp type terminals shall not be used unless approved by Urban Utilities
- Separately mounted terminal blocks/strips shall be provided for each voltage level
- Separately mounted terminal strips shall be provided for different wiring applications including control, instrumentation and power wiring
- Adjacent groups of terminals shall be separated from each other using space, barriers or earth terminals
- Terminals shall be arranged such that all cores (including spare cores and screens) of multicore and twisted pair cables fan out and terminate in a logical sequence onto consecutive terminals of a common terminal strip. The terminals strip group label in this case is the same as the cable tag number. Terminating screens of instrument cables direct to the instrument earth bar is not accepted
- Terminals for internal wiring shall be arranged such that all ‘commons’ or ‘positives’ are grouped together and bridged with a continuous link on consecutive terminals
- Each strip of terminals shall be clearly identified with a group label. In addition, each terminal in the strip shall be labelled with a unique number

- Terminal strip labels and numbers shall be defined on the relevant drawings and Project Documentation
- I/O marshalling terminals shall be grouped per I/O module and the groups of terminals shall be separated by an end bracket which is labelled with the associated controller rack and slot number
- The end terminal with exposed open side in each terminal group shall be blanked off with an end plate
- Only one end bracket shall be used to separate each group of I/O marshalling terminals
- Sufficient terminals shall be provided to terminate all cores (including spare cores and cable screen wires) of multicore cables and instrument cables
- Each terminal strip shall have at least 30% spare terminal space (including provision for field cabling)
- All unused ancillary control and monitoring channels on control equipment items within the control panel shall be wired to terminal strips for future use
- Barriers shall be installed on each side of groups of terminals used for termination of spare cores
- All PLC and RTU digital and analogue I/O channels shall be wired to marshalling terminal strips (including installed spare cards) for connection to field cabling
- Where more than one wire is to be connected to one side of a terminal for looping purposes, multiple adjacent terminals and preformed links or combs shall be provided
- Terminal strips shall be arranged such terminal screw slots and terminal numbers are visible from outside the compartment to facilitate ease of wire termination

The following requirements apply to terminals for intrinsically safe (Ex i) terminals

- Terminal points inside cabinets, junction boxes etc. shall be marked or painted blue in accordance with AS/NZS 60079.14
- Terminals used for intrinsically safe circuits shall meet the requirements of AS/NZS 60079.25 for creepage and clearance. Minimum terminal size shall be Weidmuller WDU 2.5 or approved equivalent
- Intrinsically safe terminals shall be located at least 50 mm from non-intrinsically safe terminals.

Cable terminations for Increased Safety (Ex e) equipment shall observe all requirements in accordance with AS/NZS 60079.14 clause 11.2.3, 11.2.4 and by the equipment Manufacturer's documentation. All necessary clearance and creepage distances shall be maintained.

Cable terminations for Non Sparking (Ex n) equipment shall observe requirements listed in AS/NZS 60079.14 clause 14.3.3 or in the equipment Manufacturer's instructions.

4.6.3.1 Screened and Armoured Cables

The following requirements apply to screened and armoured field cables:

Screen or Armour Type	Earthing Requirements	Continuity Requirements
Instrumentation, Communication & Control screens	Earth at PLC panel or MCC end only except where specified in Project Documentation	Maintain screen as far as possible up to the termination (i.e. do not cut screen off at the gland). Screens shall maintain continuity through all intermediate junction boxes between the field device and the control system panel
Cable armour	Earth at both ends except where specified otherwise in Project Documentation	For painted gland plates and non-metallic enclosures, use a gland equipped with a brass earthing tag or serrated washers to ensure a good earth bond. Glands must be designed for armoured cable.

4.6.4 Wire Numbering & Labelling

Numbered core markers as detailed in the relevant Project Documentation shall be fitted to each end of all wires and cores of control and LV cables.

Cable cores connected to terminals, earth bars and neutral bars shall have ferrule labels of the Grafoplast 'TRASP' system, the Grafoplast SI2000 system or an accepted equivalent system. Equivalent systems shall meet the following minimum requirements:

- Label carriers shall enclose the core completely (i.e. as a sleeve)
- Label carriers shall be of the correct size for the conductor
- Text shall be black on a background of white insulating material
- Circular type, clip-on labels, or saddle type clip-on numbers shall not be used

Ferrule labels for every LV and control cable core shall meet the following requirements:

- Power cable core identification will be by cable number, and core colour or number (core insulation)
- Ferrule labels shall be arranged to read from left to right and from bottom to top
- The same wire number shall be used on wires forming connections directly in series or parallel in the same panel
- Where cables for different items of equipment are terminated at the one location (e.g. field marshalling box) and wire numbers are the same for the different items, then each wire number shall be prefixed with the item equipment number to distinguish between the cores. This shall be done whether or not it is shown on drawings.

When wiring numbers change (i.e. at connections between equipment) a clear system of coding shall be used at the change point and details shall be clearly marked on the drawings.

The wire number conventions for existing installed control system panels shall be adopted for new control system panels of the same type at the same site, unless specified otherwise in the Project Documentation.

4.6.5 Fibre Optic Cable Type

Application	Cable Type
Out-of-Plant Control System Cables (SCADA WAN)	9/125 µm (OS2), SMOF, glass-fibre
In-Plant Control System Cables & Patch Leads (Remote I/O LAN, PLC LAN, SCADA LAN)	50/125 µm (OM2), MMOF, glass-fibre

4.6.6 Fibre Patch Leads

Refer TMS1151 *Preferred Equipment List – Control Systems* for accepted patch leads. The following requirements apply:

- Fibre patch leads shall be supplied with SC connectors
  - Under adverse conditions, such as excessive humidity or vibration, alternative connectors such as FC or ST shall be used
  - LC connectors shall only be used to connect to existing patch panels / FOBOTs / devices using LC connectors or where severe space restrictions apply
- Fibre patch leads shall not be of excessive length.
- Patch leads shall be neatly secured using a cable management system and not prone to mechanical damage or stress when accessing the panels.

Fibre patch leads shall be colour coded depending on communication function as follows:

Application	Standard Colour
Fire systems	Red
Safety Function Control Systems	Red
SCADA, electrical protection and process control	Yellow
Profinet	Green
Corporate LAN and intranet (including telephony)	Blue
Security LAN (e.g. Site Access, CCTV)	White

Rugged OM3/OM4 patch leads meeting the above requirements shall be installed where fibre patch leads are required to transition outside of an enclosure.

5 SOFTWARE & PROGRAMMING

5.1 Software Configuration

Configuration guidelines for Programmable Control Equipment presented in this section shall be followed for all Urban Utilities sites. Where existing Urban Utilities standard software code and configuration is not available the RTU, PLC, HMI and SCADA control systems shall be configured to meet the following minimum requirements:

- Adhere to existing Urban Utilities standard code where available
- Common look and feel for operation and maintenance personnel
- Simple, hierarchical structure of operating displays
- Ease of commissioning, troubleshooting and fault identification
- Modular structured logic and associated displays
- Incorporation of alarm management and alarm minimisation
- Modular configuration and programming
- Incorporation of plant wide approved standards (for example approved standard for colours, tag numbers and other display elements)
- The system shall be subject to a CHAZOP study of all control system states

The following requirements are particularly noted:

- Programming and configuration shall be designed to fail to a safe condition. This means that the system or the plant shall remain in a safe state after occurrence of process or plant faults or on failure of electric power or instrument air and system
- Essential alarms and safety interlocks shall be duplicated in the control wiring for safe operation
- The plant shall remain in a safe state after the fault or failure returns to normal
- This includes the plant or equipment not automatically starting or operating on return to normal unless specifically required to do so
- On initialisation, all critical setpoints shall be set to a predefined initial value if the setpoint is read as a value of zero. The method of pre-setting the value is depended on the technology used
- The configuration shall provide for the retention of values required to be maintained during power failures and downloads. Equipment shall always restart in a normal, operational and predictable manner after a processor reset or interruption to power supply
- Urban Utilities preference is for standardisation of all hardware, software and system configuration parameters of SCADA. Urban Utilities standard code shall be used where available and Urban Utilities preferred equipment lists applied where applicable

5.1.1 Programming Software Licences

Proprietary RTU, PLC, HMI, Communications and SCADA programming software shall be supplied unless otherwise specified in the Project Documentation. This includes and is not limited to software licences for configuration/fault finding of PLCs, RTUs, SCADA, Local HMIs, protocol gateways and other programmable devices as well as centralised asset management software such as PDM, Fieldcare, and Simocode ES Premium. Software shall be licensed to Urban Utilities.

Software, licences, associated hardware (e.g. terminals, dongles, interface cables and miscellaneous items) and documentation required to configure the control system shall be handed over to Urban Utilities at Practical Completion.

5.1.2 SCADA Server and Client Licences

The server license should be sized appropriately to allow the use of all static and dynamic points defined in the Project.

SCADA licence architecture for a site requires Urban Utilities approval prior to implementation.

5.1.3 RTU, PLC and SCADA Programming

Configuration and programming of RTUs, PLCs, communication devices and SCADA systems shall follow the accepted FS, SDS and HMI User Manuals.

RTU and PLC programs shall be designed and written using OEM standard programming software and techniques.

Rigorous configuration management procedures shall be applied throughout the project life cycle, including version control.

On request from Urban Utilities, all code developed at any stage of the project shall be submitted for progress and compliance review purposes.

Prior to commencing new software development or modifications to existing software, existing PLC and SCADA site specific software versions and licences shall be confirmed along with compatibility of existing hardware. Enquiries shall be made with Urban Utilities to determine the latest requirements.

Changes to existing control systems shall only be made with Urban Utilities authorisation. FOR603 *Control System Change Management Form* shall be completed as part of the works in accordance with PRO396 *Change Management Procedure*. Completion of all Urban Utilities Permit to Work forms and approvals shall be undertaken prior to commencement of any onsite work.

5.2 Administrative Requirements

5.2.1 File Backup and Security

All PLC programming software running on Virtual Engineering Workstations (VEWS) at Sewage Treatment Plants must be accessed via the VersionDog application. The primary means of data transfer to/from the VEWS shall be via the Urban Utilities Network Attached Storage (NAS).

Any changes implemented must be backed up every day before leaving or disconnecting from site, including work done on Urban Utilities' issued project laptops.

For guidance on access and usage of VersionDog and the NAS, refer to *WI220 Working with Virtual Engineering Workstations and VersionDog.*

In the addition of a new PLC to the plant control systems network, PLC program should be added to the relevant EWS and version dog monitoring system. From the moment the PLC is connected to the plant control systems network any change to the PLC program should be implemented from the EWS and captured in VersionDog.

5.2.2 SCADA Access & Security

For SCADA access and security requirements, refer to the Urban Utilities Digital and Information Group - Operational Technology Team – OperationalTechnology@UrbanUtilities.com.au.

The capability to enable an automatic logout system shall be provided. This function must be enabled per individual workstation. When activated, any workstation that is logged on at a level higher than 'Monitoring Only' (or equivalent) shall revert to a 'Monitoring Only' access level after a specified duration of workstation inactivity. Logging out a user will not shut down the system.

5.2.3 Logbooks

A logbook or similar system shall be maintained to capture the status of changes to site configuration and version history installed on site.

5.3 SCADA Configuration

For SCADA configuration requirements, refer to vendor-specific SCADA specifications, including TMS849 *STP Citect SCADA Configuration,* TMS1712 *STP Citect SCADA Administration Manual* and the GeoSCADA Administration Manual.

5.4 Alarms

SCADA systems will be developed with adherence to technology-specific specifications such as TMS849 *STP Citect SCADA Configuration or* TMS1712 *STP Citect SCADA*

Administration Manual. Alarm masking shall be implemented in the PLC logic routines/blocks where it is practicable to do so. The alarm suppression shall not be a global requirement such as for wet weather conditions. The methodology to achieve adherence to these requirements shall be provided.

5.5 PLC Programming

The requirements of this section apply to Urban Utilities' STPs and Network Assets, where an existing PLC control system is being modified or a new PLC is being provided. The specification excludes minor changes to PLCs where the existing programming of the PLCs does not conform to this specification. In these cases, the existing programming style and structure shall be maintained.

5.5.1 Hardware Log

PLC processor on-board status logs shall be displayed at SCADA. History, status and diagnostic data available in the PLC shall be displayed. SCADA shall store the data if communications with the PLC fails.

5.5.2 Programming Languages

The following abbreviations apply:

Term	Definition
FB	Function Block
FBD	Function Block Diagram
IL	Instruction List
LD	Ladder Diagram
SFC	Sequential Function Chart
ST	Structured Test
STL	Statement List

Allowable programming languages are defined in IEC 61131-3 "Programmable controllers - Part 3: Programming languages":

IEC 61131-3 Language	Type	Approved for Use	Rockwell Logix	GE Proficy	Siemens STEP 7	Siemens TIA
IL	Text	Yes	X	X	√ STL	TBA
ST	Text	Restricted	√	√	√ SCL add-on	TBA
LD	Graphical	Yes	√	√	√	TBA
SFC	Graphical	Yes	√	X	√ GRAPH add-on	TBA
FBD	Graphical	No	√	√	√	TBA

Notes:

- Functions are a feature of Rockwell Logix, GE Proficy and Siemens Step 7, and are approved for use. Such functions may be written as a LD, or in ST and are then referred to as a Ladder Block or a Structured Text Block. Generically they may be referred to as a function block, but this is different from the FBD graphical language.
- Structured Control Language (SCL) is the Siemens STEP 7 implementation of the ST programming language
- Statement List (STL) corresponds to the IL language
- GRAPH is the Siemens STEP 7 implementation of the SFC language

Programming languages shall be applied as follows:

Application	FB (ST/LL)	FBD	SFC	Requirements
General	√	X	X	• Developed using Urban Utilities libraries based on FBs called from LD subroutines • Function blocks used for generic code only • Example code can be supplied on request • Code generally written in LD using object orientated formatting and data structures • ST restricted to function blocks
Sequential Logic	√*	√	√	• Real-time control of sequential processes • Other complying programming languages may provide some elements of SFCs
Drive Interlocking Logic	X	√	X	• Real-time interlocking of drives, on/off valves and process equipment • Faults/interlocks shall be visible to operators • Drive blocks shall be programmed with separate block inputs between Interlocks, Remote-Manual Permissives and Remote-Automatic Permissives • Blocks shall not be write-protected • Blocks shall be fully annotated with source code provided
Regulatory Logic	X	√	X	• Necessary facilities for real-time regulatory control and monitoring of the process

Application	FB (ST/LL)	FBD	SFC	Requirements
Calculations	√	X	X	• Simple calculations expressed using FBs • Calculations with detailed formulae, array references or iterative processes shall be Add-on Instructions (Global function blocks) expressed using ST • Results shall be verified with sample values and their known predicted results • Where reused, complex calculations shall be encapsulated, then called in a subroutine or modular block • Blocks shall not be write-protected • Blocks shall be fully annotated with source code provided

5.5.3 Program Naming and Revision Control

Program naming shall be according to the following format:

<Site_ID>PLCnn_YYYY-MM-DD

where:

Field	Description
<Site_ID>	The short representation of the Site ID, for example ST018 for Luggage Point
nn	The PLC number on site
YYYY-MM-DD	Date

Example:

ST018PLC01_2012-05-07 Luggage Point (ST018) PLC1 on 07/05/2012

5.5.4 Library Use

During the development of PLC code, priority shall be given to the reuse of program blocks copied from the “PLC standard code library”.

Specific requirements are detailed in the respective library specification:

- TMS1707 *Siemens S7 PLC Library Specification*
- TMS1708 *GE Fanuc PLC Library Specification*
- TMS1709 *Rockwell Logix PLC Library Specification*
- TMS1710 *Siemens TIA PLC Library Specification*

Prior to any program block modification or creation, authorisation shall be gained from Urban Utilities. This is to ensure consistent and efficient support of the library from project to project, determining whether:

- A standard program block is reused (without change to the library)
- A standard program block is reused with the addition of logic surrounding it to modify the overall effect (without change to the library)
- A standard program block is modified (with update to the library)

A new program block is created (with possible addition to the library)

Modified or new program blocks must be submitted to Urban Utilities for review, approval, and at the discretion of Urban Utilities, added to the PLC standard code library.

If a standard block is approved by Urban Utilities for modification, either:

- The minor version number shall be incremented
    - backward compatibility must be retained

or

- A new block with a new name is created from the existing standard block.
    - The existing version history must be retained, but must be marked as historical and reference the existing standard block
    - The version number shall recommence at 0.1

Modifications of standard blocks shall conform as closely as possible to the existing code structure.

5.5.5 Program Comments

Comments shall be added to the program to segregate logic into functional areas of operation to enhance readability. Functional areas of operation include individual rungs, networks or sections of code.

Refer to the below for an example:

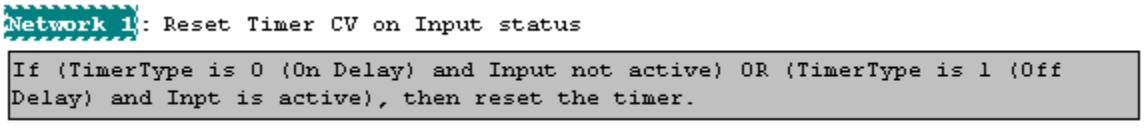


Figure 3-1 - PLC Network comment example (Siemens PLC)

Comments appearing on logic during programming/configuration shall also appear on any logic monitoring displays and any hard copy printout or self-documentation of the same logic.

Hard copy printouts or self-documentation of the logic shall include comprehensive identification of the location of that logic and descriptive comments/titles that clearly identify the associated plant equipment and the purpose of the logic.

5.5.5.1 Headers

The code revision history must be incorporated as a comment at the beginning of the program, including:

- Revision (Major.Minor)
- Date
- Author full name
- Author company name
- Description of changes made
- Functional Specification document number

The major revision number must be incremented upon a PLC upgrade, or commissioning of a new section of plant. Otherwise, a minor revision number must be incremented for each quantity of minor works (e.g. a single access to make amendments or a single day's amendments). Refer to the figures below:

Figure 3-2 - Revision History on a GE Proficy PLC

```
This section of code provide the generic functions for the PLC code.

Version 1.0 10/01/2005 DJH Initial Release
Version 1.1 10/01/2006 DJH Included PLC Time-Of-Day Code
Version 1.2 22/03/2005 DJS Included STO_DATE for 2AM Time Synchronisation
Version 1.3 24/04/2005 NPG Modified driving of "Midnight" pulse
```

Figure 3-3 - Revision History on a Siemens PLC

Program modules shall have a header comment describing the operation of the module. For example, drive logic shall include:

- Title including the plant area
- Drive description
- Drive number

5.5.5.2 Sequence Steps

Comments shall be inserted at every definable state and transition to provide a description of the purpose of the state and the conditions required to enable the transition.

5.5.5.3 Complex Logic

Comments shall be inserted to provide information about and an explanation of complex logic. Refer to the below for examples:

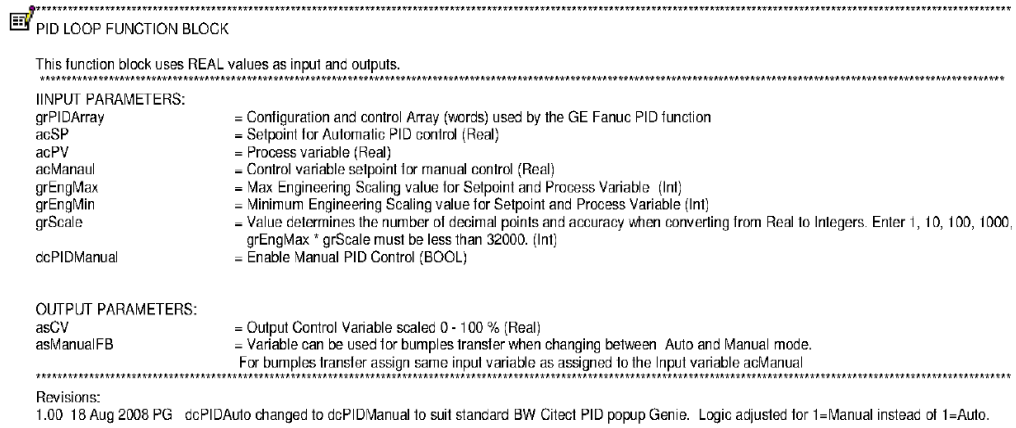


Figure 3-4 - Complex logic comment example (GE PLC)

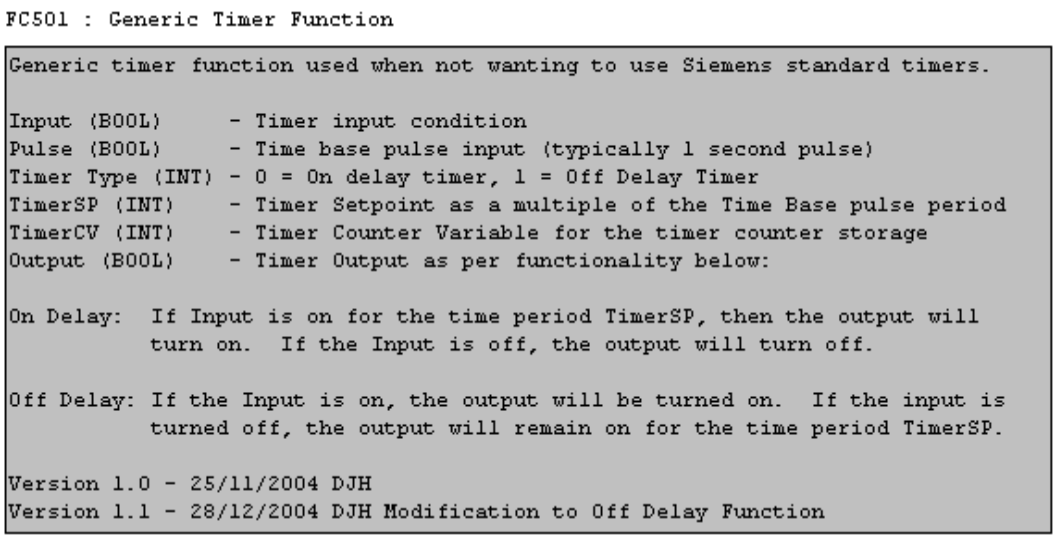


Figure 3-5 - Complex logic comment example (Siemens PLC)

5.5.5.4 Calculations

Calculations shall be commented to ensure ease of understanding. Constants used shall be explicitly identified. For example, a constant 101.32 may be labelled *Reference_Pressure_kPa*. If a constant is the result of a combination of factors, how the constant is arrived at shall be commented to facilitate readability and future modification of the constant if one of the factors needs to be changed.

Complex calculations done over multiple rungs shall be preceded by comments providing a detailed overview of the following code. Refer to the below for examples:

```
**********************************************************************************************************************************
POLY FLOW DETERMINATION.

The Poly Flow is determined according to the Following Equation

Feed Flow (kl/Hr) * Feed Concentration (mg/L) * Poly Dosage Rate (kg/Tonne)
_____________________________________________
Poly Batch Concentration (mg / L)


@ a Typical Feed Flow 9 l/s
                                    = 9 L/s = 30kL/Hr
                                    = 30 kl/Hr @ a Feed Concentration of 3% = 30000mg / L  (30 g/L)
                                    = 970 kg /Hour of Solids

@ a Poly Dosing Rate of 3 kg/Tonne
                                    = 970/1000 * 3 = 2.9 kg/Hour of Poly Required

@ a Poly Concentration of 0.18%  1800 mg/Kg
                                    = 2.9 kg/Hour / (0.18/100)
                                    =1620 L / min
                                    = 27 L/min
**********************************************************************************************************************************
```

Figure 3-6 – Example complex calculation description as comments (GE PLC)

```
Network 5 : n-Length Filtering
The RawValue is filtered by performing an n-length filtering algorithm, with
the length in seconds being defined in the FilterLengthSP setpoint.   The
filtering is performed by the execution of the following equation every one
second:

Value = ((Value * (FilterLengthSP - 1)) + RawValue) / FilterLengthSP

If filtering is not required, then the FilterLengthSP should be set to 1.  This
will update Value every 1 second with the RawValue.

If filter length is zero, then the Raw Value is copied direct to the Value

DBD16 = acFilterLength
DBD20 = asRawValue
```

Figure 3-7 - Example complex calculation description as comments (Siemens PLC)

Rungs containing calculations shall include a detailed comment detailing the formula being used.

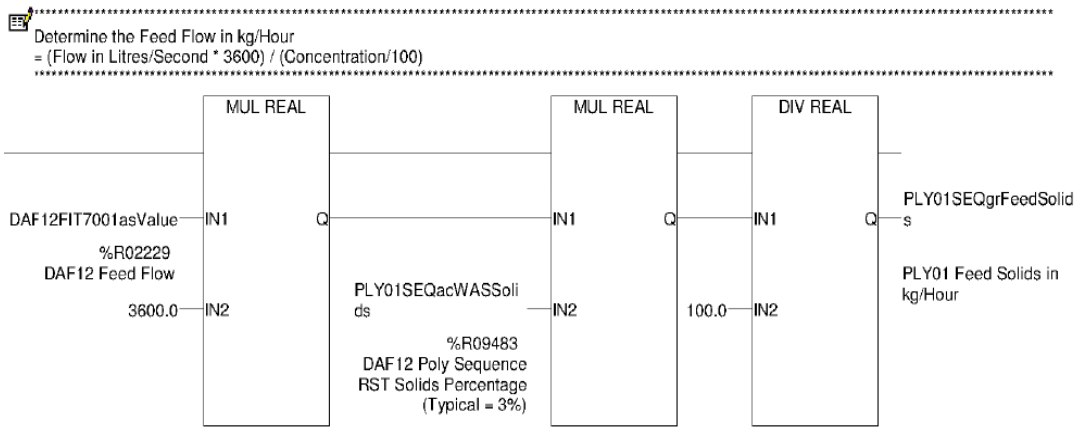


Figure 3-8 - Example rung comments (GE PLC)

5.5.5.5 Function Block Comments

Function blocks shall be commented to clearly depict the duty being performed.

For example, a PID block shall be commented with:

- The tag number that will call up the associated faceplate
- The descriptor associated with the control loop or PID block as appropriate

Where the selected system supports embedded fields on the function block diagram referencing the above (tag, descriptor and engineering units, if applicable), then embedded fields shall be used preferentially to provide this information. Additional comments providing the balance of information not available in embedded fields are required.

It shall not be necessary to 'drill down' to obtain detail on global variables used, inputs, or outputs. These details shall be listed in comments or shown on the function block diagrams if not inherently listed or displayed.

The interconnection and interaction of analog and digital logic blocks on the function block diagrams shall be clearly depicted. If referencing within a function block is not apparent at diagram level, then the connections shall be illustrated by commenting or another suitable method.

User-defined function blocks shall be liberally commented, with particular attention to commenting of input and output parameters.

5.5.6 Programming Requirements

Each output should have its own dedicated rung of logic.

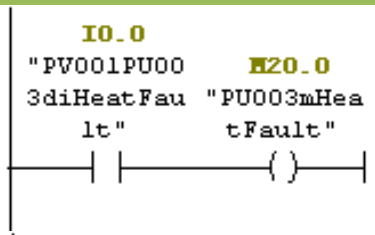
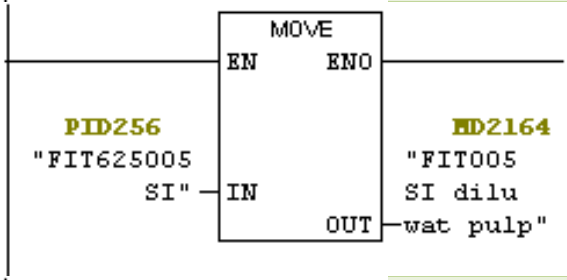
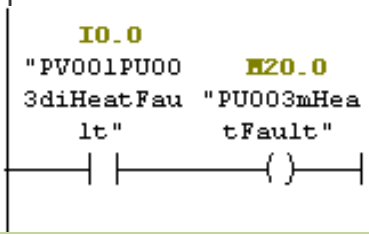
Except for timer and counters, embedded constant values in ladder logic should be avoided. Program constants should be assigned to the data block.

Bits set by SCADA from outside the PLC software directly controlling the device should be reset upon use by the PLC software concerned.

Analog values shall be scaled to engineering unit values (x1, x10 or x100 for the purposes of resolution) in the PLC using a scaling function block.

Programs on new PLCs shall take up no more than 80% of the capacity of the CPU Logic I/O or Variables to allow future modifications or additions.

PLC physical I/O shall be mapped to memory words & bits. PLC physical I/O should not be used in logic routines. Logic routines should be created to map internal memory words & bits to PLC physical I/O. The below examples are taken from Siemens STEP 7 PLCs:

I/O Type	Type	Address Type	Ladder Diagram
Digital Input	M	Bit	
Analog Input	MD	Double Word	
Digital Output	M	Bit	
Analog Output	MD	Double Word	

5.5.7 Programming for Failsafe Control

Control logic shall de-energise relevant sections of the plant upon the following conditions:

- Equipment failure, such as:
  - PLC processor, rack or module failure

    - PLC to PLC communication failure where this transfers equipment interlocks
- Power failure, such as:
    - Mains power failure
    - Control power supply failure

The de-energised state shall be deemed the safe state.

The PLC shall control the plant safely without reliance upon the SCADA/HMI.

Any critical safety inputs/signals like a high-level switch input shall be 'on' or logical '1' state in healthy state. Any tag or symbol description state should be 'on' or logical '1' state. For example, a tag for pump fault *dsPumpFault* will need to be 'on' during a fault.

5.5.8 Sequence Programming

Refer to Appendix E – Sequence Example for an example of an accepted sequence program.

If several control actions must be executed in sequence, a state sequencer shall be implemented.

Each sequence shall be implemented in its own program block.

A state sequencer may only be in one state at a time. Each state shall be defined by a unique integer number. It is usual practice to number the states in sequence, commencing from 0, then 1, 2, 3 etc. Though this is recommended, this is not mandatory, except for the 0 (idle) state. The idle state shall be the default state adopted upon PLC start-up and must drive no device activations.

Each possible sequence state shall also activate an associated unique digital flag. These digital flags along with the conditions required shall be tested to drive the transitions between states.

Transition between states shall be controlled by conditions comprising device or process conditions, and / or timing.

A sequence always has an idle state and may have a completion state, though it is conceivable that there may be requirement for a sequence with no clearly definable completion state.

The sequence is running when the sequence is in a state other than the idle state.

The sequence shall commence running upon the activation of an explicitly defined sequence start interlock and transition conditions.

An explicitly defined sequence run interlock shall enable the sequence to run following start-up. If the run interlock is lost, the sequence shall safely transition to a shutdown state or the idle state.

Once a sequence has transitioned to the completion state, it shall automatically transition back to the idle state. This transition shall be controlled by a timer of length adequate to support visual feedback of the completion state to the Operator.

Provision shall be made to allow insertion of additional steps in future if required.

Each sequence step should have a timeout alarm, if the step is taking more than the specified time a timeout alarm will trigger and if safe transition to the 0 (idle) state.

Where a sequence state drives the plant, the state must drive clearly defined control actions and setpoints, which are then utilised by the device control program blocks.

The sequence program block shall not control devices directly.

Where multiple sequences must interact, a master sequence shall be created to control them. Only when all these sub-sequences have completed, may the master sequence complete.

Sequences to fully automate plant start-up and shutdown upon Operator initiation shall be created.

5.5.9 Process Requirements

5.5.9.1 Parameter Initialisation

Process parameters which are critical for plant operation shall be:

- Stored in non-volatile memory
- Initialised with hard-coded values on the first scan if those value are zero

These include, at minimum:

- Analog scaling ranges and filtering parameters
- Alarm set points
- Process set points
- PID parameters
- Mode selection

The hard-coded values should be determined during commissioning and updated as required or upon recommissioning of the plant.

5.5.9.2 PLC Startup

Timers shall be implemented upon PLC start-up (e.g. after power failure recovery) to delay the commencement of the process to allow plant stabilisation, and to inhibit nuisance alarms until such stabilisation.

A staged start shall be implemented for equipment with significant start-up currents (e.g. large motors or banks of motors) as identified in the site's Power System Analysis report. A suitable delay shall be introduced between starts for such equipment to minimize the plant's peak current.

5.5.9.3 Load Shedding

If applicable, load shedding shall be implemented to inhibit running of non-critical motors while the site is running on generator power.

5.5.9.4 Interface Processing

Interface signals shall be processed in a consistent manner prior to their use elsewhere in the program passed on to the field:

- Digital I/O
- Analog I/O
- Digital alarms

5.5.9.5 Drive Standard Logic

For each type of drive, standard drive logic for repeat use throughout the project shall be developed where not provided by Urban Utilities. The use of standardised logic embedded into standard user defined function blocks is preferred, providing this is supported by the selected control system.

Typical drive function blocks shall contain the following logic:

- Mapping of Inputs
- Drive Availability logic
- Interlocks
- Auto Run Command
- Specific device trip/alarm logic

5.5.9.6 Drive Modes of Operation

Drives shall generally have three modes of operation including LOCAL, OFF and REMOTE. The site-specific functional specification shall outline the modes of operation. A consistent method of display and changing the drive mode on plant graphics shall be implemented. The following control modes shall be supported for controlled devices.

Selector	Local Mode	Off Mode	Remote Mode		
HMI Selection	N/A	N/A	Manual	Auto	Out of Service
Control	Physical pushbuttons	Hardwired de-energised	HMI control buttons	Plant sequences	Unavailable for remote operation

Emergency Stop pushbuttons de-energise the device in all modes.

Local Mode

The operator can select this mode by operating the “Local/Off/Remote” selector switch at the equipment site to “Local”. The selection of this mode is indicated on SCADA. The operator can start and stop (or open and close) the equipment at the equipment site independently of the SCADA system while in this mode.

The drive will stop if the operating mode is switched to Remote while running in Local.

Upon return to Remote, the drive will resume the mode it was in before it was switched to Local. This means that a remote manual start will be required if the mode is Remote/Manual, or if in Remote/Auto, the drive will start if the automatic logic requires it to.

Off Mode

This mode may be selected at the equipment site by selection the “Local/Off/Remote” selector switch to “Off”. When equipment is placed in the Off Mode, the equipment cannot be operated either manually or automatically by the control system, and no alarms are generated for this equipment.

Controlled equipment is defined as being available if the equipment is not in the Off Mode and it is not in a Fault state. This mode is generally used for maintenance purposes.

Remote Manual Mode

The Remote Manual Mode can be selected on SCADA when the equipment is in remote by selecting the “Manual” button. When equipment is in Manual Mode, it is remotely controlled from SCADA by selecting Start and Stop (or Open and Close) buttons.

The remote manual control of the equipment is only possible if the following conditions are met:

- Manual Interlock Condition – the equipment can be started if the defined manual interlock conditions are met
- Fault Condition – The equipment can be started if the fault condition is not active

If the equipment fails to start or stop (or open or close) within a specific time after the command is issued, then the equipment will be put into a Fault state, and an alarm will be raised on SCADA.

If equipment is running in Remote Automatic Mode, and Remote Manual Mode is selected, then the equipment will continue to run and it will adjust its speed or position (if applicable) to the Manual Setpoint set on SCADA.

Remote Automatic Mode

The Remote Automatic Mode can be selected on SCADA by selecting the "Automatic" button. This mode is the "normal" mode of control for all devices within the plant. When equipment is placed in the Automatic Mode, the control of the equipment is defined by a series of conditions, set points, and delay times as follows:

- Automatic Start/Open Condition – this condition is logical expression controlled by the equipment's automatic sequence, that when true starts/opens the equipment
- Automatic Interlock Condition – the equipment can only be started if the defined automatic interlock conditions are met.
- Fault Condition – The equipment can only be started if the fault condition is not active.

If the equipment fails to start or stop (or open or close) within a specific time of the automatic commands, then the equipment will be put into a Fault state, and an alarm will be raised on SCADA.

Automatic sequences are groups of equipment that run together under automatic control, according to a defined series of steps, loops, times, and interlocks. The normal operation of these sequences is that they are constantly in running mode, but the facility exists for the operator to start and stop the operation of the sequence. Each sequence has "Start" and "Stop" control, and a Running/Stopped feedback to show the status of the sequence.

Setpoints and times required for the logical equations for automatic sequence control are adjustable from SCADA. The operator input for setpoints is limited to a safe operating range defined for each setpoint.

If equipment is running in Remote Manual Mode, and Remote Automatic Mode is selected, then the equipment will run as per automatic conditions defined above.

Remote Out of Service Mode

The Remote Out of Service Mode can be selected on SCADA by selecting the "Out of Service" button. This mode is used to indicate that the equipment is out of service on the SCADA system.

5.5.9.7 Drive Duty Operation

Duty Assist Control

Equipment can be in the Duty control configuration if the process requirement is at times not able to be provided by a single item of equipment operating, (i.e. requires the operation of 2 or more pieces of equipment). Individual Start and Stop conditions are defined for each piece of equipment required to operate.

If the Duty (n) equipment is unavailable (Faulted, Disabled, or Manual Stop), then the Duty (n+1) equipment is to continue operating with the duty equipment parameters. The duty changeover is operator-selectable remotely from the SCADA as:

- 1 = Duty A, 2 = Duty B, etc.
- 2 = Duty A, 1 = Duty B, etc.
- Auto changeover

In Auto changeover mode, for equipment that stops and starts, the duty will change every time the Duty A equipment stopped stops, and for equipment that runs continuously, the duty will change when the duty equipment has been running continuously for 24 hours.

If the Duty A equipment fails, then the Duty B equipment shall immediately become the new Duty A equipment if available.

Duty Standby Control

Pumps may be in the Duty/Standby Control configuration if the process requirement can be provided without all pumps operating. Start and Stop conditions are defined for the operation of the Duty Pumps.

If the Duty Pumps are unavailable (Faulted, Disabled, or Manual Stop), then the Standby Pump is to operate in place of the Duty Pumps. Pump Duty is operator-selectable remotely from the SCADA as Duty, Standby, and Alternate.

- 1=Duty, 2=Standby
- 2=Duty, 1=Standby
- Auto changeover

In Auto changeover mode, for equipment that stops and starts, the duty will change every time the duty equipment is stopped, and for equipment that runs continuously, the duty will change when the duty equipment has been running continuously for 24 hours.

If the Duty equipment fails, then duty shall failover to the Standby equipment and it shall become the new Duty equipment.

Tripped drives in a duty/standby arrangement shall require an operator reset of the trip before any restart can occur. Note that if the plant is undergoing transitions from normal power to emergency power and vice versa, automatic resetting of any latched software drive trip will be required.

5.5.9.8 Drive Alarm Management

Unless otherwise stated, the occurrence of any drive alarms will cause the control system to remove the run signal to the drive.

Drive Status Indication

For each drive, at least the following states shall be provided for operator display purposes and for other logic:

- Auto Selected
- Remote Manual Selected
- Drive Running
- General Fault (NB. Could be Thermal Overload or other fault)
- Stopped, Not Ready to Start
- Interlocked
- Stopped, Ready to Start
- Failed to Stop
- Failed to Start

For each drive, at least the following states shall be displayed on the custom plant graphics.

Status	Functionality
Tripped	Latched on by drive in the run state being tripped by a safety or equipment interlock. Reset by a restart of the drive.
Interlocked	Indicated when drive is prevented from running in Remote mode by a process interlock. Different types of interlocks shall be displayed including the individual interlocks. Permissive and interlocks shall be clearly displayed and differences able to be readily distinguished. The development of hierarchical logic for device and system interlocks shall be thoroughly documented.

Drive Interlock / Permissive

Drive interlock logic shall reflect the specific tripping requirements of the particular drive as well as a ‘failed to run’ trip and shall be programmed in the standard drive function block.

Drive interlocks shall not cause an alarm to be generated if the drive was not running or starting.

There are three types of drive interlocks and each shall have different functionality as described in the following table.

Interlock	Example	Functionality
Safety Interlock	Stop Button, Thermal Overload, Pull Wire	Hard wired, cannot be over-ridden. Inputs to control system configured for monitoring, alarming, tripping of drive logic.
Equipment Interlock	Seal Failure, Belt Drift, Blocked Chute, Failed to Run, Trip	Inputs to control system configured for monitoring, alarming, tripping of drive logic. Able to be bypassed by configured logic.
Process Interlock (Auto / Manual Permissives)	Downstream equipment status, Process levels, flows and pressures.	Inputs to control system configured for monitoring, alarming, stopping of drive logic. The drive is stopped until the process condition returns back within its operational range. The drive will then be enabled to operate as required. Able to be bypassed by configured logic. Bypassed in 'MAINTENANCE' Mode. No alarm for drive, only for the process interlock.

Process Interlock / Permissive

A process interlock is also commonly referred to as permissive. A process interlock may cause a drive to stop and an event shall be recorded in the Event Log, however will not generate a drive trip alarm for that drive. This is because the stopping of the drive is a consequence of another event that is subject to the alarming defined for that event.

New device function blocks shall provide for Remote Manual and Remote Automatic permissive/interlock inputs. The function block inputs are to be ON when the permissive / interlock is healthy.

For example, if drive A is interlocked to stop when drive B is stopped then:

- If drives A is running and drive B stops then no drive trip alarm is generated for drive A
- If the cause of drive B stopping is a trip then a drive trip alarm is generated for drive B only
- If the cause of drive B stopping is that the operator stopped it from the drive faceplate, then no alarms are generated for drive A or for drive B
- If the cause of drive B stopping is an interlock from another drive then a drive trip alarm is generated for that other drive only

5.5.9.9 Drive Run Time Indication

Drive run indication shall be provided for each drive. Duration of run time logged before rollover shall be a minimum of 10 years. Run time shall accumulate with a resolution of one second.

If time accumulators with the above characteristics are not supplied as a standard part of the control system, then a standard function block with a retentive timer and one or more counters shall be implemented.

5.5.9.10 Valve Standard Logic

Urban Utilities standard valve software shall be implemented in PLC and SCADA where applicable.

For each type of valve controlled by the PLC, standard valve logic for repeat use throughout the project shall be developed where not provided by Urban Utilities.

Typically, standard valve control logic types shall include On-Off valves (with various forms of feedback) and motorised valves.

Valve Common Requirements

Logic execution speed shall be appropriately selected for the service.

Valve Mode Selection

Consistent methods of display and changing of control mode similar to drive control shall be developed for all types of valves to be used within a project.

In mode transition if the valve is operating in Remote Manual or Automatic mode, and Local Manual mode is selected, the valve will remain in its current position.

5.5.9.11 Valve Operator

The control logic for a valve shall provide the necessary flags for faceplates and popup graphic windows that shall be provided for the operator. These displays shall include the following:

- Position Status Indication — Open / Closed / Indeterminate
- Analog Position Indication — % Open and % Feedback
- Mode Indication — Maintenance / Manual / Auto / (Cascade, Ratio, Computer)
- Fault Control Status Indication — Interlocked, Tripped, Ready for Sequence Control
- Valve Icon
- An Alarms Section shall display the possible alarm conditions for the valve. Existing alarms shall be differentiated from dormant alarms by colour change or highlighting. Alarms to include ‘Failed to Open’ and ‘Failed to Close’ indications
- An Interlocks Section shall display the permissive conditions for valve operation
- The current state of each permissive shall be differentiated by colour change or highlighting
- Control buttons for mode control
- Control buttons for manual control

5.5.9.12 Valve Alarm Management

General Valve Alarm Logic

Unless otherwise stated, the control system must attempt to maintain the desired position of the valve regardless of the occurrence of any alarms generated by that valve.

Valves with Open/Close Limit Switches

Valve position feedback (Open and Closed limit switches) shall both be installed and connected into the PLC on every installation unless otherwise specified. A valve's position feedback shall not be simulated using the valves command signal.

Valves with limit switches shall generate an alarm if they do not achieve their target state within a pre-set individually adjustable time. When a 'failed to open' or 'failed to close' alarm is generated, the target will be maintained unless altered by operator action or other logic that has been specified.

Valves with limit switches shall generate a discrepancy alarm if the limit switches indicate a mutually exclusive state (such as both open and closed indicated).

Valve Device Interlocking

Valve interlock logic shall reflect the specific tripping requirements of the particular valve.

Valve Process Interlocks

A process interlock may cause a valve to change state but will not generate a valve trip alarm for that valve.

This is because the operation of the valve is a consequence of another event that is subject to the alarming defined for that event. This is a similar concept as described in Drive Interlocking — Process Interlocks.

5.5.9.13 PID Control

Urban Utilities standard PID software blocks shall be implemented in PLC and SCADA configuration where applicable.

Where not provided by Urban Utilities the standard logic for PID control shall be developed and shall include the following:

- Remote Manual control of the final element (e.g. pump speed, valve position) shall be through the PID controller
- Setpoint limit clamping
- Output limit configured within the PID controller
- Setpoint Ramp control (only if required)
- Operator selection on SCADA between Cascade and Single Loop control modes

- Bumpless transfer for;
  - Cascade to Single Loop
  - Single to Cascade Loop
  - PID Manual to Auto mode
  - PID Auto to Manual mode
  - System initialisation
- Bumpless transfer during mode selection between two separate PID controllers e.g. The operator selects valve control between Flow PID or Pressure PID. The transition between Flow control and Pressure control shall be bumpless
- Prevention of integral windup
- SCADA PID popup windows shall allow for direct engineering parameter manipulation, setpoint by control systems engineers
- Retention of all PID tuning parameters on cold restart of CPU.
- Tuning parameters shall be trended

Control Loop Diagrams

Control Loop Diagrams shall be provided for complex control systems. The Control Loop Diagram shall be referred to in the site-specific functional specification.

Loop Tuning

Loop tuning results and trends shall be submitted after commissioning for:

- Setpoint Step-Response
- Process Load Disturbance

5.5.9.14 Calculations

Calculations shall be carried out in engineering values, not raw values.

Ensure adequate error trapping is used, for example, check for zero value to avoid divide by zero errors before all divisions.

5.5.9.15 Reporting

The program shall accumulate certain values and make it available to the HMI for daily reporting. Current day's data shall be accumulated and made available to the HMI as it is being accumulated. At a pre-set time each day, the HMI activates the End of Day (*dcEOD*) tag in the PLC. Upon the End of Day tag activation, the PLC shall move all "current day" values into the associated "yesterday" tags, and shall then reset the End of Day tag.

The following data, as a minimum, shall be accumulated:

Description	Current Day Tag Suffix	Yesterday Tag Suffix
Drive Run Hours	asHours	asHoursYDay
Drive Run Minutes	asMinutes	asMinutesYDay

Description	Current Day Tag Suffix	Yesterday Tag Suffix
Drive Starts	asStarts	asStartsYDay
Valve Operations	asOperations	asOperationsYDay
Flow Totals	asTotal	asTotalYDay
Power Totals	asTotal	asTotalYDay

5.5.9.16 PLC Status

Standard PLC status bits and the health of all communications links shall be made available to the HMI.

For example:

- Hardware faults such as PLC Running/Stopped Status and Configuration Errors
- PLC rack faults
- I/O card errors
- Communication errors

5.5.10 Program File Structure

5.5.10.1 Logic Structure

A hierarchical structure that links higher-level modules (such as sequence logic modules) to lower level logic modules (such as those controlling individual drives) shall be defined. This structure will group logic modules for the various plant areas and subsystems in a manner that simplifies the navigation through the configuration logic.

The program shall be structured as a calling hierarchy, “GOTO” and “JUMP” commands must not be used. The following table details the various blocks that should be implemented and how they relate to each other.

Name	Example	Contents	Calls	Note
Main Program Block		Calls	Administrative program blocks or Section program blocks	First block executed
Administrative program blocks	Generic PLC functions PLC status and faults PLC to PLC comms PLC to device communications Test code	Logic	Library program blocks	
Section program blocks		Calls	Section sequence program block or Device program blocks	First block dedicated to a plant section

Name	Example	Contents	Calls	Note
Section sequence program block		Logic		
Device program blocks	Control program blocks Status program blocks Sequence program blocks	Logic	Library program blocks	
Library program blocks	bwAlarm bwANALOG bwPID	Logic		Copied from "PLC standard code library"

The following is an example implementation (GE) of a calling hierarchy:

- *_MAIN* is the first program block, which is run whenever the PLC is in run mode, and which calls the section control block:
- *a_PreTreatment_Main*, which calls the device control block:
- *FCV2000_PostGritAerationValve*, which calls the standard control block e.g. bwALARM

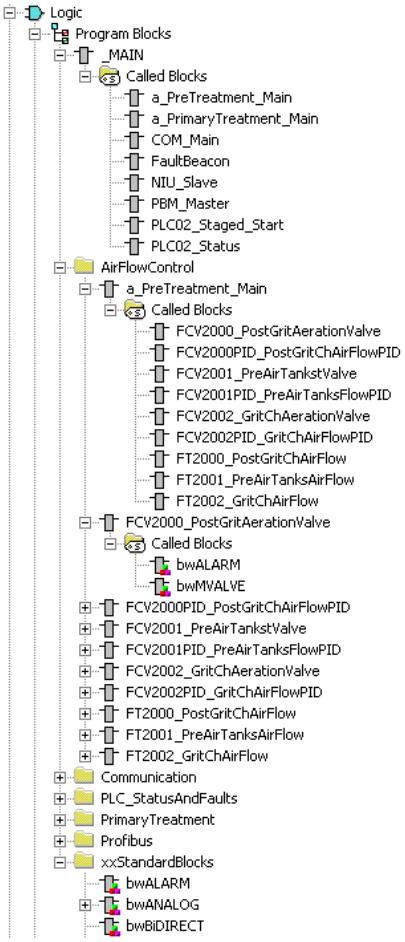


Figure 3-9 - PLC Program Structure (GE PLC)

5.5.10.2 Logic Modules

For PLC programs reused across multiple sites under the same Works, a standard program shall be developed with site-specific setup parameters defined. Program modules shall be designed as standard repeatable implementations and proven by testing.

Compilation of standard programs shall include Urban Utilities stakeholders detail review and acceptance of the software.

PLC software code shall be composed of simple, formally structured logic modules, each carrying out clearly defined tasks (e.g. control & interlocking logic for a drive or a PID control loop). Logic modules shall each contain one coherent plant system from a commissioning perspective.

Where possible, regulatory and sequence control for a specific system should be grouped together.

Readability of the logic shall take priority over compactness of coding.

Modules shall minimise interlocks or signals required from other modules.

Only one logic module or function block shall write to any output field (e.g. a flag, output etc.).

Blocks shall not to be write-protected. Password protected or locked code is not accepted.

5.5.10.3 Logic Location

Logic shall be configured and executed in the same controller where the I/O for the logic is configured. Peer to peer controller communications shall be minimised.

Any peer to peer communications shall be described and documented in the Control Systems Administration Manual. The documentation must detail the consequence of failure of the remote peer data to the local plant.

Where peer to peer communications are used, logic shall detect that the communicated values are valid and current prior to use. Analog watchdog alarms shall be incorporated into networked PLCs where robust hardware failure detection is not provided. Failure of the watchdog will trigger an invalid alarm. Critical signals shall be relocated to the PLC performing the control function where possible.

5.5.10.4 Order of Execution

The execution order of logic shall minimise the number of logic scans for a change in the system to propagate through the logic.

The main routine shall only call individual subroutines. It shall not contain process functionality.

5.5.10.5 Order of Appearance

Program logic module lists (e.g. a hierarchical tree display) shall be grouped first by plant area, then by category of equipment and then in alphanumeric order.

5.5.10.6 Grouping of Modules in Folders

Where module can be grouped into folders for programmer convenience, grouping shall be by plant area.

Folders shall be named by area, followed by a descriptive name. There shall be a clear distinction between the devices and where they are used within plant control.

5.5.10.7 Segregation of Elements

A system of reserving various programming elements, flags and memory blocks based on functional grouping criteria shall be defined in the process control system specification. For example, flags used for a single drive or purpose may be grouped together. The objective is to provide structure by setting guidelines if the structure does not inherently exist.

5.5.10.8 Signal Monitoring

Whenever possible, trip and alarm signal monitoring functions shall be implemented using the same built-in function block features used for control signal monitoring.

Critical safety interlocks shall not share functionality with process control functions.

5.5.11 Communications

Communications Type	Requirements
Peer to Peer	Where peer to peer communications are required, a heartbeat value shall be included with each transfer. This value shall change with each transfer and at a set rate. The value shall be used to verify the integrity of the transfer. Upon loss of communications, control logic reliant upon communications shall default to a safe state.
Device and Instrument	A program block containing management of communications via buses (e.g. Profibus, Modbus, Ethernet etc.) shall be developed for each communications channel used. It shall include required initialisation, monitoring, diagnostics and alarming.

Communications Type	Requirements
HMI	Communication between PLCs and HMIs shall be managed by the HMI. If required, the HMI shall monitor the communications link to determine online / offline status.

5.5.12 Device Control

Device logic shall control the operation of drives, valves and other devices based on field I/O and Operator interaction via the HMI.

Logic shall be structured as follows, as appropriate for each device's functional requirements.

Topic	Requirements
Available Logic and Interlocks	Logic determining if the device is available to be operated in either local or remote, based on its faults and alarms. "Available" is equivalent to a run interlock. Also includes interlock logic including start, run and auto control interlocks.
Sequence Activations	Activations from the state sequencers are translated into the device specific flags for automatic control of the device.
Device Control	Device functional requirements. Standard library blocks should be used where appropriate (e.g. common valve or drive control blocks). This section includes device specific calculations, conversions and accumulators. Real world inputs, if required, are used here including any required pre-processing.
Reset Command	Device reset commands (individual triggers or as part of a group of devices). Logic to map these conditions into the device reset flag is placed in this section.
Status, Alarms and Faults	Logic to set a flag based on alarm/fault status, followed by logic to trigger alarms and faults.
Outputs	Device specific digital and analog outputs are mapped here including any final filtering or scaling.
Reset Command Bits	The final logic will clear any digital commands (dc tags) which have been acted upon by the device control logic.

5.6 SCADA & HMI Graphics

5.6.1 General Principles

Where not defined in this Specification, additional graphics requirements shall be defined in the HMI User Manual to suit the selected process control system. The HMI User Manual shall be accepted by Urban Utilities as part of the detailed SCADA

configuration specification prior to HMI graphics configuration work being finalised and shall be updated to As Built status after commissioning is complete.

Graphics shall show all necessary detail. A standard approach shall be described:

- Detail not generally required while operating shall be accessed at a lower level of graphic windows accessed from touch/cursor points
- To avoid cluttering graphics with information that is only needed occasionally, such detail shall be hidden until required. For example, options to hide or display descriptors, tag names, minor process lines or data lines can be provided to the operator.
- Related data shall be grouped into tables rather than displayed individually

Where possible, display of equipment and piping shall be standardised and orderly:

- Process line colours shall conform to project colour standards
- Main process lines shall be displayed as thicker than minor or ancillary process lines
- Process lines and minor equipment (e.g. valves) shall be displayed either vertically or horizontally
- Where practical, symbols from Urban Utilities standard libraries shall used. Where not defined in standard libraries, symbols for process elements shall be based on standard ISA 5.1 Instrumentation Symbols and Identification
- Equipment and device status shall be indicated by symbols, text and colour
    - Colour alone shall not be relied on to indicate the status of an object

Each screen shall display the last successful poll in the top right-hand corner and the communications channel (i.e. radio modem or other comms link) receiving the information.

Refer to the existing Urban Utilities site standards for legacy SCADA implementations, including ClearSCADA, Mosaic, Radtel and SCADA-C. For Citect SCADA implementations, refer to TMS849 *STP Citect SCADA Configuration* and TMS1712 *STP Citect SCADA Administration Manual*.

5.6.2 Hierarchy of Graphic Displays

Category	Requirements
Plant Overview	• A single Custom Overview graphic of the whole plant • Provide access to Plant Area Overviews
Plant Area Overview	• Custom Overview graphics of individual Plant Areas • Provide critical control parameter monitoring information • In general, no provision of operator control access • Enable operator access to Operating Graphics & Trend Overviews • Compliant to existing plant specific SCADA graphics display hierarchy

Category	Requirements
Trend Overview	• Permit the operator to easily navigate to a particular trend display
Operating Graphics	• Basic custom graphics used by operators for monitoring and control • Provide operators with clear, comprehensive process monitoring and control via a process view (like a P&ID) that mimics the plant • The number of Operating Graphics per plant operating area shall be determined by the complexity of the plant being depicted
Detail Graphics	• Provided when more detail is needed than normal Operating Graphic E.g. the operating graphic may show a compressor as a single graphic entity complete with 'group' states of the entity but the detail graphic for the compressor displays all the drives (main and auxiliary, oil lines and filters) with individual status of each device shown
Diagnostic / Status Pop-up Windows	• Provided for drives, valves and systems where interlocking can trip or interlock out that equipment

5.6.3 Navigation

The configuration for a standard method of navigation provided for the plant operator shall be described. Methods of interfacing the operator with a hierarchical structure of display screens shall be consistent.

5.6.4 Colours

The standard graphics colour scheme defined below shall be used on all graphic displays. Colours for custom graphics are defined in Section 3.6.5 Custom Graphics. Standard colours have been defined to achieve a common look and feel across sites.

Page backgrounds are to be 'grey' from the colour palette, according to the library page templates.

The following standard colours shall be used for all animated objects, as configured in the library:

Equipment Type	Status Colours
Pump, Motor, Mixer, Screen, Screw etc.	Running = RED Stopped Ready to Run = GREEN Faulted = Flashing Red
Valve, Reflux etc.	Open = RED Closed = GREEN In Transit = GREY Faulted = Flashing RED

5.6.4.1 Alarm Colours

Standard alarm colours shall be used for the display of all alarms as configured in the library:

Alarm State	Colour	Description
Ack-Off	White	Acknowledged and Off
Ack-On	Red	Acknowledged and On
Disabled	Blue	Disabled (Alarm Disabled Page Only)
UnAck-Off	Flashing Yellow	Un-Acknowledged and Off
UnAck-On	Flashing Red	Un-Acknowledged and On

5.6.5 Custom Graphics

5.6.5.1 Display of Data

Aside from level indication, quantities shall generally be displayed in SI engineering units, not as a percentage of full scale.

For level indication, 0 to 100% indication shall be used except in special cases requiring the display of an engineering value. Level shall be indicated as a numerical percentage value near the vessel. Levels may also be depicted graphically as a bar.

In the water network facilities, level and pressure shall be displayed in mAHD.

Data shall be displayed to at least 3 significant digits.

5.6.5.2 Graphical Buttons

Graphical buttons shown on mimic displays and faceplates shall:

- Visually distinguish between the ‘pressed’ and ‘normal’ states
- Be selectable and operable by mouse. In general, graphical buttons shall activate on a ‘mouse-Button-up’ so that it will be possible to cancel the action of clicking on a button by moving the mouse pointer away from the button before releasing the mouse button.
- Remain visible but ‘greyed out’ when their functions are not currently available
- Be selected to a sensible default on dialog boxes, pop-ups and control faceplates. Examples of sensible defaults are ‘Cancel’, ‘Exit’ and ‘Ok’

5.6.5.3 Graphic Objects

Objects may be used on the screen to show specialised equipment, including photos or CAD drawings. Objects status animation including colour, modes etc. must align with Urban Utilities colour conventions and standards refer Section 3.6.4 Colours.

5.6.5.4 Display of Drives

Drives shall be displayed on the process graphics as an icon or symbol.

Drive status shall be denoted by animation as per Section 3.6.4 Colours. Display of Maintenance/Manual/Auto Mode and Tripped/Interlocked states shall be achieved by dynamic text display. Text colour may be modified to reflect normal or alarm indication as appropriate.

Display of running status for bidirectional drives shall be as per single direction drives with additional direction arrows. Direction arrow colours shall be dynamically set based on direction/running status (refer to Section 3.6.4 Colours). An individual Diagnostic/Status Graphic shall be associated with each drive.

An individual Drive Control Faceplate shall be associated with each drive. Drive Control Faceplates permit stopping/starting and display drive status and mode.

5.6.5.5 Diagnostic Status Graphics

Diagnostic/Status Graphics provide diagnostic/status information for a drive, valve or system. These are generally popups displaying summary tables of interlock, alarm and operating states.

The Diagnostic/Status Graphic indicates:

- The current state of each interlock (healthy/unhealthy)
- The cause of the last trip
- The mode of the drive or system
- The running/starting/stopped, tripped, ready/not ready state of the drive or system

5.6.5.6 Display of Valves

Valves shall be displayed as an icon or symbol.

- Operating mode shall be indicated adjacent to the valve icon.
- An individual Diagnostic/Status Graphic shall be associated with each interlocked valve
- An individual Device Control Faceplate will be associated with each valve. Device Control Faceplates permit opening/closing of valves and display the status and mode of the valve.

5.6.5.7 Sequence Status Displays

Sequence Status Displays are single, comprehensive operator graphic displays providing operational/diagnostic information on an individual sequence. Requirements are as follows:

- Operators shall not be required to read/decipher logic or code to understand the sequence
- The overall status of a sequence shall be displayed
- States may include 'Inactive', 'Starting', 'Stopping', 'Tripped', 'Ready/Not Ready'
- Progress shall be meaningfully displayed. Operators shall be able to determine the full sequence of actions in the sequence. The currently performed action shall be highlighted.
- If a sequence involves time delays, delay progress shall be shown as a numeric display of the remaining time. This requirement may be waived for short time delays.

5.6.5.8 Display of Duty/Standby Systems

Equipment in duty-standby arrangements shall have their current duty status displayed on operating and detail graphics where each device appears.

Individual Diagnostic/Status graphic popup displays shall be provided for each duty/standby system. From this display the operator shall be able to determine:

- 'Running'/'Stopped/Ready'/'Stopped/Not Ready' status of each device
- 'Duty'/'Standby'/'Out of Service' status of each device
- 'Tripped' status of each drive

5.6.5.9 Trends

Redundancy shall be implemented via a Primary and redundant Secondary server:

- Trend data shall be synchronised to ensure continuity of trend functions and prevent gaps in historical data in the event of a server failure
- Operator involvement shall not be required
- Server status shall be monitored. Server failure shall produce a diagnostic alarm.
- Communications failure between the two servers (e.g. broken ring network) shall force both to interrogate all I/O Devices. On resumption of communications, servers shall re-synchronise. This functionality will be dependent on the capability of site SCADA.

Trend display requirements are as follows:

- Unless otherwise specified, trend pens shall be assigned for all analog process variables.
- Trend displays shall be as per site standard and as per standard trend template screens (where applicable). Where not provided, a template for trends shall be developed.
- Trend displays shall be archived at three-month intervals.
- Trends shall be displayed using process analyst objects.

5.6.6 Operator Displays

Screen update time is a key performance criterion:

- Screen update time shall be ≤ 2s for all points shown, except by written approval
    - Approval will be granted only where the channel is bandwidth-restricted
- Nominated screen update time shall be supported by calculations, naming all assumptions
- Screen update times shall be accepted by Urban Utilities before works commence

I/O Server requirements are as follows:

- Trend points shall be scanned according to the configured trend period
- Alarm points etc. shall be scanned only as needed (e.g. when the page is displayed)
- Polling traffic shall be minimised by read and write caching of data
    - For Citect 1000ms is an acceptable caching time
- Addition of new PLCs and devices shall not cause communication issues for existing PLCs

SCADA HMI display requirements are as follows:

- Existing site display conventions shall be maintained to ensure a consistent look and feel
- SCADA shall not limit the number of graphic displays possible
- Graphics pages shall be displayable by selecting screen targets
- It shall be possible to call displays based on a variable's condition (e.g. upon an alarm)
- Pop-up windows for trends, loops and device status pages shall be available
- Displays shall show the page name, current login details, current time and date together with details of the last alarm that has occurred
- Reusable and uniform library objects shall be used
- Moving animation shall not be used
- User-configurable colours shall be available
- It shall be possible to define colours as flashing between any two colours. When multiple objects on a page flash, each object shall flash synchronously.
- If communications to an I/O point have failed, a visual indication of invalid data shall be shown wherever that data is normally displayed

5.6.7 HMI User Manual Specification

The HMI User Manual Specification shall define the following:

- Items accessible via mouse/cursor/touch points, including access to drives, valves, control loops, data, selections, sequences, pop-up windows, detailed graphics and menus
- Criteria defining parameters assigned to trend pages
- Criteria defining parameters assigned to historical data logs

6 INSTALLATION & SETUP

6.1 General Requirements

Equipment manufacturer's installation recommendations shall be kept available on site and shall be reviewed prior to the commencement of any installation works. Control system components shall be installed strictly in accordance with the manufacturer's instructions and the relevant Project Documentation. Any conflict between Project Documentation and the manufacturer's recommendations shall be brought to the attention of Urban Utilities for resolution. Where manufacturer's instructions are not available, details of the proposed installation method shall be accepted by Urban Utilities prior to commencement of the works.

6.1.1 Workmanship and Personnel

Personnel engaged in the installation of control system hardware components shall be accredited, suitably experienced, competent and skilled in the field of work in which they are engaged. Installation works shall be completed by or under the direct supervision of fully qualified tradespeople holding trade qualifications and certificates adequate for the work and licensed under Queensland regulations.

Profibus and Profinet design and installations shall be performed by persons trained and certified by the Profibus and Profinet Association of Australia http://profibusaustralia.com.au/.

Persons undertaking control system works shall be directed by experienced qualified supervisors who shall be responsible for the works and for ensuring personnel are conversant with and comply with Urban Utilities' Safety Rules and Regulations, particularly those rules controlling work permits.

Urban Utilities reserves the right to inspect all works and direct re-work if the works are not in compliance with the project specifications or commensurate with acceptable trade practice.

6.1.2 Mounting of Equipment

Equipment, enclosures and instruments shall be mounted as per the requirements of TMS1732 *Electrical & Instrumentation General Specification*.

Refer to Section 2.3 Control System Panels for equipment mounting requirements in control system panels.

6.1.3 Removal and Decommissioning of Equipment

Decommissioned control system panels, including equipment contained within, shall remain the property of Urban Utilities and shall be locked, packaged, labelled, loaded,

and removed from site, and delivered to and unloaded at a location indicated in Project Documentation.

Decommissioning shall include the safe and effective removal and off-site disposal of all decommissioned cables and conduits, waste plant and/or equipment in accordance with all current legislation and local, regional and state/national statutory requirements.

6.1.4 Care and Maintenance

Systems shall be installed and configured for easy maintenance and minimal operational disruption. Effort shall be made to maintain system availability during the following:

- Installation of new software
- Installation of additional system hardware
- Installation and testing of software patches, upgrades, enhancements
- Renewal of any licenses

All personnel shall comply with good housekeeping requirements on site. These shall cover management of tools, equipment and rubbish to ensure a safe working environment .

Plant areas shall be kept free of cut cable ends, cable strippings and other accumulation of rubbish. Rubbish shall be collected and disposed of daily in accordance with the approved site procedure. Only those materials and equipment required for immediate use shall be stored within plant areas. Tools and loose items shall not be left or stored inside control system panel enclosures.

Flammable debris shall be removed prior to working with naked flame tools, welding, cutting or grinding equipment. Equipment shall be protected from damage by grinding, drilling, swarf, grit blasting etc. Fire blankets shall protect equipment and materials near flame cutting or welding.

Equipment shall have doors kept closed with covers and gland plates firmly in position when not being worked on to prevent dust and moisture ingress. Gland plates shall be removed prior to drilling (i.e. not drilled in-situ). After terminations in an enclosure are complete, the enclosure shall be thoroughly cleaned using suction cleaners.

6.2 Materials and Equipment

6.2.1 Supply

All materials and equipment necessary to make a complete and fully functional installation shall be supplied in accordance with Project Documentation.

For all non-specified equipment, TMS62 *Preferred Equipment List – Electrical* and TMS1151 *Preferred Equipment List – Control Systems* shall nominate the preferred suppliers and/or equipment. These requirements shall not be deviated from without

prior written approval from Urban Utilities. Where the materials are not specified, standard materials suitable for the application, environment and operating/design conditions may be offered. Non-specified equipment shall be of the same type, grade and quality as similar items specified in Project Documentation. Corresponding parts of similar equipment shall, where possible, be interchangeable.

Materials and equipment shall be of standard manufacture and readily available from Suppliers unless specified otherwise in Project Documentation. Equipment shall be sourced from local OEM (Original Equipment Manufacturer) authorised distributors within Australia.

Materials shall be new and comply with the relevant specifications, regulations, codes and standards.

All materials shall be free from:

- Refractory Ceramic Fibre or High Biopersistence Fibre
- Radioactive materials (unless specified otherwise in Project Documentation)
- Mercury

Dangerous goods shall be labelled and identified in accordance with the project requirements. Hazardous materials shall be supplied with a safety data sheet (SDS).

6.2.2 Handling, Storage & Preservation

Materials shall be stored, handled and preserved in accordance with Project Documentation.

Project Documentation will define material and equipment to be received and stored on site. Such equipment shall be immediately inspected upon receipt for damage sustained during transit. Any damage shall be notified in writing to Urban Utilities and suitable action agreed with Urban Utilities to minimise any work schedule delays.

The safety, security and preservation of equipment and materials received shall be maintained for the duration of the Works. Equipment and materials shall be stored in a suitable location and environment in accordance with the Supplier's recommendations to prevent any damage, deterioration or corrosion prior to installation. Preservation schedule shall be as per manufacturer recommendations.

Equipment shall be protected from adverse moisture, vermin, debris and dust ingress during construction.

6.2.3 Surplus and Scrap Materials

Surplus materials resulting from works at Urban Utilities sites shall remain the property of Urban Utilities and throughout the Works shall be collated, sorted and delivered to the locations as advised by Urban Utilities.

Scrap materials shall remain the property of Urban Utilities unless advised otherwise in Project Documentation. Scrap materials shall be handled in accordance with the project procedures or as agreed with Urban Utilities.

Waste materials shall be disposed of in accordance with the accepted Environmental Management Plan.

6.3 PLC Hardware Setup

6.3.1 Hardware Configuration and Diagnostics

The RTU/PLC diagnostics buffer shall be expanded to store a minimum of 500 records upon initial hardware configuration.

Repetitive hardware alarms shall not consume the diagnostics buffer.

At minimum, evidence shall be provided of the following:

- Zero errors within the diagnostics buffer RTU/PLC during FAT and SAT
- Minimum of 20% spare processing capacity
- Minimum of 40% spare memory capacity (including on-board removable memory cards) to allow the future addition of working memory, non-volatile variables, timers and counters
- Minimum of 20% spare installed I/O of each card type

As a minimum the CPU shall be configured to handle the following faults:

- Loss of remote I/O nodes
- Rack faults
- Module faults
- Channel faults
- Communication errors
- CPU or NIU backup battery low
- Failure of field bus instruments and devices
- Missing Function Blocks or data

The CPU shall not be password protected.

Retentive memory shall be retained after a hot-restart, warm-restart and a cold-restart.

6.3.2 I/O Module Arrangement

I/O modules shall be assigned in the RTU/PLC as follows:

- D Failure of a single I/O module shall not result in total loss of operation of all equipment in a duty group (e.g. *Pump1* and *Pump2* should not be wired into the same I/O card)
- Analog inputs used in a cascade PID loop shall be distributed across two separate analog cards if a second card is installed. Failure of the second analog card will drop the PID controller from cascade back to single loop control.
- Critical signals shall be hardwired directly into the device performing the critical control function where practicable. Inter-PLC signals for critical control functions shall be minimised and/or rationalised

6.4 Signs and Labels

6.4.1 External Labels

Enclosures shall have tag labels permanently attached in accordance with Project Documentation and the equipment schedules. Where it is not practical to mount labels on the enclosures they shall be mounted on the adjacent steelwork or equipment mounting bracket stand, clearly visible from the walkway or operating position. Equipment tag name labels shall not be attached to cladding.

Fixing shall be by a minimum of two stainless steel screws. Labels larger than 75mm x 25mm shall have four fixing screws. Fixing of labels shall not void the IP rating or certification of the equipment. Attachment by means of adhesives shall not be permitted, except for HA enclosures and where accepted by Urban Utilities.

Fixing holes in labels shall be drilled oversize and screws shall not be tightened to the extent that the label cannot move under expansion caused by extremes of temperature.

Standard Label Drawings shall identify labelling requirements and shall detail label materials, label size, text size, label configuration as well as fixing arrangement for each type of label. A typical label of each type shall be submitted to Urban Utilities for approval prior to ordering or manufacturing.

Refer to TMS1647 *Plant and Equipment Tag Numbering* for details on how equipment shall be tagged.

The following shall have UV stabilised exterior grade acrylic labels attached:

Application	Label Colour	Text Colour	Notes
Control System Panel enclosures	White	Black	Including control system panels and junction boxes
Enclosures for safety-related systems	Red	White	

Label letter height shall be generally as follows:

Label Type	Text height (mm)
Equipment Number	30
Equipment Title/Description	20
Max Voltage Level and Upstream Isolation	20
Sub-Equipment / Component Labels	5
Pushbutton Designation	3.5

When placing labels on HA certified equipment, care must be taken to prevent invalidating equipment certification. Drilling or modification of certified enclosures is not permitted. Labels attached to certified enclosures must not cover the enclosure's own certifying label. Fixing shall not compromise the IP or hazardous area rating of the equipment.

6.4.2 Internal Component Labels

Equipment within enclosures shall be clearly labelled for positive identification as per Project Documentation. Equipment labels inside enclosures shall be white/black/white ABS plastic laminated engraving material (e.g. Traffolyte) with bevelled edges.

Internal labels on gear trays or escutcheon panels shall be secured by M3 chrome plated metal threads or glued into position with industrial grade adhesive. Internal labels elsewhere shall be glued into position. Double sided tape or self-adhesive labels are not acceptable methods for fixing labels.

Where an item of equipment is removable or has a removable part, such as doors, covers, plug-in-component and the like, then the removable part shall be similarly identified.

Labels shall be positioned as follows:

- Adjacent to or as close as possible to the relevant equipment
- Preferably above the relevant equipment
- To provide unobscured visibility from outside the enclosure with the doors open
- Not secured onto ducting
- Not fixed directly onto equipment in case the part is replaced in future

Terminal labels shall meet the following requirements:

- Each strip of terminals shall be clearly identified with a group label
- Each terminal in the strip shall be labelled with a unique number
- Terminals shall be equipped with provision for affixing individual terminal numbers
- A non-adhesive, vibration resistant system shall be used for affixing individual terminal numbers

Labels shall be provided to indicate the main isolator for each voltage level in the control system panel, as well as for each circuit breaker.

Potential electrical hazards within enclosures shall have warning labels complying with Australian Standards that provide indication of the voltage level. Control system panels installed in publicly accessible areas shall have relevant danger warning labels fixed to the external door.

Isolated neutral circuits where present in the panel shall be identified with a warning label.

Label letter height shall generally be as follows:

Label Type	Text height (mm)
Enclosure Number	30
Enclosure Title/Description	20
Max Voltage Level and Upstream Isolation	20

Label Type	Text height (mm)
Equipment Labels	5
Pushbutton Designation (Internal to Enclosures)	3.5

A label list shall be checked by the Contractor for compliance with TMS1647 *Plant and Equipment Tag Numbering* prior to manufacture and be made available for review by Urban Utilities.

6.5 Quality Assurance, Inspection and Testing

Full compliance with this Specification and Project Documentation shall be demonstrated.

6.5.1 Quality Assurance

A quality assurance system accredited to AS/NZS ISO 9001 shall be applied to all works. The system's effectiveness and compliance with it will be subject to monitoring by Urban Utilities and in addition, may be audited following an agreed period of notice.

A quality control program shall be submitted for Urban Utilities' review in the works proposal and when agreed shall apply for the Works. Cooperation with Urban Utilities and Urban Utilities' nominated inspectors and auditors shall be furnished during all stages of the works with respect to quality assurance compliance.

Witness points shall be identified for access by Urban Utilities when applicable.

6.5.2 Program of Works and Scheduling

A delivery program showing all stages of the Control System implementation including design, testing, and hardware procurement and commissioning and the program shall be integrated with the overall project delivery schedule. The integrated program shall be submitted in draft version with the proposal.

The program shall be updated to indicate resources nominated to each task. The critical path shall be clearly identified. The program shall be updated with task percentage completed for the duration of the project and submitted to Urban Utilities for information with each project progress reports. Frequency of progress reporting will be specified in Project Documentation.

The delivery program shall provide a detailed breakdown of works. The breakdown of elements shall be aligned with the Design Management Plan and shall consider stakeholder constraints and procurement of long lead time items.

Note: Urban Utilities requires 10 business days to review any document submitted for review. The program must allow for this constraint and shall indicate initial and final issue of all key documents.

The schedule or works program shall have the following key document start and end date milestones nominated as a minimum:

- Software and Documentation Development Tasks
  - I/O List
  - Process Control Narrative
  - Functional Specification Document
  - Control System Software Requirements
  - HMI User Manual
  - Control System Administration Manual
  - Individual PLC Program Development
  - SCADA Servers Configuration
  - SCADA and HMI Screens Programming
  - Network Equipment Configuration (Switches, Routers, Modems)
- Hardware and Software Validation and Verification
  - Software Simulation Testing of Individual PLC programs (Bench testing)
  - Software Simulation Testing of HMI and/or SCADA Terminals (Bench testing)
  - Control System FAT (PLC and SCADA)
  - Control System Cut-over Plan
  - Control System SAT (PLC and SCADA)
  - Control System Site Commissioning (PLC and SCADA)
- Procurement, Manufacture, Installation and Commissioning
  - Delivery of long lead items
  - Assembly and manufacture of Control system panels
  - Site installation for each individual PLC
  - Site installation for SCADA and HMI Terminals
  - Site inspection, testing and commissioning of each plant area
  - Proof of performance testing for each plant area
- Project Finalisation
  - Final (backdrafted) As Built Documentation submission
  - O&M Manuals
  - Training

6.5.3 Test Equipment

Test equipment shall be supplied, certified and traceable to an applicable standard. A list of test equipment along with copies of calibration test certificates shall be kept on site and shall be available for Urban Utilities review upon request during SAT.

Test equipment shall have a Test Accuracy Ratio of ≥3:1. Test Accuracy Ratio is defined as follows:

$$Test\ Accuracy\ Ratio = \frac{Accuracy_{(Equipment\ Under\ Test)}}{Accuracy_{(Calibration\ Equipment)}}$$

Test equipment shall be calibrated within six months of the test date.

Test and calibration records shall be maintained and form part of handover documentation.

Records shall include the correct asset tag number, range, voltage and nameplate information as a minimum. Urban Utilities and the supplier shall be notified of deviations from nominal values.

6.5.4 Incoming Equipment Inspections

Equipment shall be inspected upon arrival at site for damage and conformance with the purchase orders, specifications and all other relevant documentation. An incoming equipment ITP shall be developed detailing exact inspection requirements.

6.5.5 Installation Inspections and Testing

Urban Utilities shall always be permitted free access to all parts of the Works that concern execution of the Works including on-site workshops and storage facilities.

All required test equipment, tools and materials shall be supplied. These shall be fit for purpose, in good working condition and calibrated. Calibration certificates shall be maintained for all relevant equipment.

Control system hardware site installation works shall be visually inspected for:

- Correct installation in accordance with issued drawings
- Acceptable workmanship and quality
- Accessibility for operations and maintenance
- Compliance with Urban Utilities specifications

Inspection sheets shall demonstrate that installed equipment has been thoroughly inspected. Defects discovered during Inspection and Testing shall be corrected to comply with the specified standards.

6.5.5.1 Inspection and Test Plan (ITP)

Typical Inspection and Test Plans (ITP) covering on-site installation in shall be included in proposal documents. ITPs shall list typical inspections and tests proposed for all elements of the works.

Prior to works commencing, ITPs shall be customised for the project works and may be reviewed and accepted by Urban Utilities. Final versions of ITPs shall be jointly endorsed by Urban Utilities, and will thereafter form part of Project Documentation. ITPs shall encompass the testing requirements of all relevant standards, statutory/regulatory requirements. ITPs shall define QA documentation (including test records, manufacturing certificates, checksheets etc.) used to demonstrate compliance to the requirements and required for milestone sign-off.

Installation works shall include planning and execution of all inspections and tests, with Urban Utilities having the right to witness any inspections or tests.

ITPs shall be completed and signed off progressively during the execution of the works.

Urban Utilities shall be notified, at least 4 days in advance, of dates of inspections or tests nominated as Hold or Witness points on the ITPs.

Where appropriate, test check-sheets shall state values for all test results. Tests for which the results are indicated as pass or fail shall be qualified by the relevant acceptance criteria.

For PLC and/or RTU code related testing the Urban Utilities ITP Template – TEM717 should be used where possible.

6.5.5.2 Cables

Before applying power to the control system equipment all cable inspection and tests shall be signed off by the accountable party as complete and compliant to standards, with test records available for Urban Utilities inspection.

Cable ITPs shall detail the exact test requirements for all control and communication cables. The following tests shall be conducted on each cable core at minimum:

Cable/Wire	Test	Notes
All Copper	Continuity	Results shall be recorded on checksheets
All Copper	Insulation Resistance	• Results shall be recorded on checksheets • Sensitive electronic components shall be disconnected during insulation testing • Test voltage shall be compatible with the cable
Fibre Optic	OTDR	Results shall be recorded of for length, transmission anomalies, and end-to-end attenuation
Control/Comms	Termination checks	Termination diagrams shall be marked up, signed and issued as evidence of the checks
Control/Comms	Cable label checks	Cable schedules shall be marked up, signed and issued as evidence of the checks
Control/Comms	Termination tightness	Results shall be recorded on checksheets

6.5.5.3 Earthing and Bonding

The Contractor shall test control system equipment earthing to existing earthing systems, including continuity of earth to protective earth bars, instrument earth bars, doors, equipment enclosures and individual equipment earths.

6.5.5.4 Control & Communications Panels

Control & communications panels ITPs shall detail test requirements. The following tests shall be completed where applicable:

Item	Test	Notes
Panel	Completeness check	Results shall be recorded on checksheets
Enclosure	Visual inspection	• Check quality of manufacture • Results shall be recorded on checksheets
Labels	Visual inspection	• Check rating plates, equipment labels • Label schedules shall be marked up, signed and issued as evidence of the checks
Cables & Wiring	Cable checks	Refer to Section 4.5.5.2 Cables
Busbars	Insulation Resistance Tests	Results shall be recorded on checksheets
Earthing	Earth tests	Refer to Section 4.5.5.3 Earthing and Bonding
Panel	Simulate field devices	• Energise control cables at their operating voltage, including pushbuttons, indicating lights and switches • Results shall be recorded on checksheets
Control circuits	Function tests	• Check switch & pushbutton operation • Check interlocking between switches & doors • Results shall be recorded on checksheets
Analog loops	Range test	• Test with variable input signal across loop range • Results shall be recorded on checksheets
Controllers	Operation test	• Test with variable input signal • Results shall be recorded on checksheets

If Urban Utilities carries out spot checks of the completed control system panel and discovers inconsistencies with the test records or drawings provided, the entire control system panel shall be retested with Urban Utilities witnessing.

6.5.6 Software Simulation Testing

Software validation and verification shall take the form of comprehensive in-house simulation and testing. This process shall be captured by formal testing documentation.

Software simulation testing is typically performed with the RTU/PLC processor, HMIs, SCADA terminals, I/O servers and other controllers connected via temporary network hardware. Software code used to simulate test conditions generally resides in the RTU/PLC processor.

Software simulation testing requirements are as follows:

- Simulation software internal or external of the RTU/PLC shall be developed for testing
- Simulation Function blocks used to emulate pumps, valves, varying tank levels etc. shall incorporate realistic time delays reflecting process conditions as closely as possible
- Simulation software blocks shall be accepted by Urban Utilities prior to functional testing
- Temporary tag names prepared for simulations shall be distinctively identified for easy deletion or disabling prior to integrated FAT

- Simulation function blocks and code shall be kept within separate subroutines and deleted prior to integrated FAT
- Urban Utilities may witness part of, or all software simulation tests

Urban Utilities' sole responsibility concerning Software Simulation Testing shall be to witness tests. Urban Utilities may elect not to witness every test and will advise which tests will be witnessed. Tests nominated to be witnessed shall be pre-tested with QA documentation completed. Testing shall proceed in accordance with the accepted Software Simulation Test Plan and to Urban Utilities' satisfaction regardless of Urban Utilities' choice to witness tests.

6.5.6.1 Software Simulation Test Plan

A Software Simulation Test Plan in accordance with the Software Test Strategy (refer to Section 1.10.11 Software Test Strategy) shall be submitted to Urban Utilities for acceptance prior to software testing. The plan shall enable validation and verification of control and monitoring software functionality, and outline test activities for RTUs, PLCs, HMIs and SCADA.

The Software Simulation Test Plan shall include at minimum:

- The Software Simulation Test Plan
- Overview and detailed description of the software bench test setup and methodology
- Block diagram showing connections of all equipment included in the test
- Hardware versions and software revisions
- Local HMI and SCADA server HMI screen point simulation testing including menus, navigation buttons, links within popup windows, multi-screen functionality
- Field control station simulation
- Test communication to external RTU, PLC and SCADA networks where applicable
- Individual pump and valve standard subroutine deployment tests
- Test all modes of operation for each device
- Sequence testing
- SCADA system testing
- Full bench test functional testing (including network communications)
- SCADA tags list (all points tested to HMI screens)
- Alarm list
- Setpoint list, including minimum and maximum limits
- Power cycling to all devices
- RTU/PLC download and memory wipe recovery
- Process recovery from within sequences
- Inter-RTU/PLC communication failures
- HMI screen update times
- Redundancy and failover

The Software Simulation Test Plan shall meet the following requirements:

- Software shall be tested for and in compliance with Urban Utilities accepted versions of key documents, (e.g. Functional Specification, Software Design Specification, HMI User Interface Manual, Software Test Strategy)
- The software testing officer and the programmer shall not be the same person unless accepted by Urban Utilities in writing
- Proposed changes to Project Documentation to resolve issues revealed by simulation testing shall be proposed to Urban Utilities for acceptance
- Alarms shall be simulated both to visual fault statuses on devices and HMI alarm pages
- Trends shall be simulated to HMIs
- Trend scaling shall be checked against the I/O list parameters
- Each section and paragraph in the Functional Specification and HMI User Manual detailing a functional requirement shall be covered by a corresponding test sheet activity
- Test sheets and test steps shall clearly reference the section(s) and paragraphs of the Functional Specification or HMI User Manual being validated
- The revision of the Functional Specification shall be recorded on test sheets

6.5.6.2 RTU/PLC Code Testing

Where multiple RTUs/PLCs are of similar I/O and setup, a software test of each type is sufficient.

For individual pump code testing, the full RTU/PLC, including remote I/O drops, shall be set up on the bench, with either test code or a simulator used to activate physical I/O. Simulation test code is permitted to provide equipment feedback I/O (e.g. Pump Run output can trigger the Pump Running Input via software code).

Individual device software code test shall verify, at minimum, all instances of the following:

- Full inter-PLC I/O (Master to Pump PLCs etc)
- Equipment start/stop sequencing
- Equipment start and run interlocks
- Equipment modes, alarms and events, including setpoints and mode selection
- Operator commands (i.e. start, stop resets and setpoints) including confirming boundary limitation for analog setpoints
- Configuration of hardware redundancy and communication link status for all devices
- How equipment failures and remote I/O failure modes affect operation of other process control equipment

6.5.6.3 Software Functionality Testing

Functionality testing shall be performed and documented prior to Urban Utilities witnessing tests. Urban Utilities will request evidence of test results prior to commencement of bench test witnessing.

Once each piece of equipment has been fully tested to verify software functionality, the overall control profiles shall be tested testing using historical data from the site (if available).

Full sequence testing shall be undertaken for both dry weather and wet weather scenarios to confirm start-up/shutdown/ramping sequences are fully operational and conform to the station restriction (as detailed in the functional specification and operating protocol).

In addition to the normal operating functionality, all foreseeable failure modes shall be verified as detailed in the operating protocol. The following shall be tested at minimum:

- SCADA Server redundancy (where applicable)
- RTU/PLC failure modes
- Simulation of well levels, flow rates, pressure and equipment status I/O
- For multiple sets of equipment, failure of single drives to ensure correct shutdown, duty rotation and start up occur:
    - Failure of multiple drives (all drive combinations)
    - Failure of ancillary equipment (valves, brakes, cooling pumps etc.) required for equipment operation
    - Failure of interlocked equipment
- Sections of the functional specification not previously tested in individual drive code testing shall be verified in the full bench test
- Black start of RTU/PLC (after complete loss of power). The RTU/PLC shall initialise with valid operator setpoint and process default setpoints on restart of the processor.
- Instrument under range / over range / invalid scenarios – particularly wet well level instruments
- A method of emergency operation of one drive under manual mode shall be documented
- Transitions between modes
- Faults occurring during mode transitions

6.5.6.4 Functionality Testing Template

Functionality test sheets shall describe testing methods sufficiently to allow replication of testing and results.

Test sheet page headers shall clearly identify:

- Title of the Functional Specification under test and revision
- Document name
- Document revision number
- Project name
- Project number or Urban Utilities contract number (if applicable)
- Date

Test sheet page footers shall indicate:

- Document number
- Page number
- Total number of pages

Test sheets shall be broken down into sub-headings clearly listing:

- Functional Specification section number and title reference
- Specific tests being carried out under the sub-heading
- Tag name of equipment under test

Tests shall specify the following within the order specified:

Order	Section	Description
1	Prerequisites	Conditions required before the action is to be performed. Setpoints values and input values shall be specified.
2	Test Action	Operator action/s required to trigger the test
3	Test Number	Numeric identifier for the test within the section
4	Expected Result	The test's pass/fail criteria
5	Actual Value	Resultant values (excluding pass/fail results)
6	Pass Checkbox	Each predicted result shall be individually listed with its own pass check box. Each test shall be initialled upon a successful result. Defects shall be noted on a Defect Register with reference to the exact test number. The Defect Register shall be attached to the test sheet. Once fixed and witnessed by Urban Utilities, the test sheet shall be updated with a pass date and time.
7	Comments	Any notable or unanticipated criteria or conditions shall be noted in this space. If space is insufficient, a reference note shall be inserted. Reference notes may be listed at the end of the test sheet.

6.5.6.5 User Acceptance Testing

User Acceptance Testing shall occur upon the conclusion of Functional Testing. Urban Utilities will propose realistic scenarios not already covered in the functional testing. All proposed test scenarios and results shall be recorded at the end of the functionality test sheets. Failure to successfully perform under a realistic proposed scenario shall be recorded and classified as a defect.

Additional test requests by Urban Utilities shall be allowed for during each phase of the testing. This should not be more than 5% of the agreed test plan for each phase.

6.5.6.6 Software Simulation Testing Notification

Urban Utilities shall be given written notice of the commencement of software simulation testing. Notice period shall be as per prior written agreement or ten (10) working days.

Urban Utilities will not witness tests until the Software Simulation Test Plan has been accepted.

A schedule of daily testing activities shall be issued to demonstrate that all proposed tests can be executed in the time allocated.

6.5.6.7 Software Simulation Test Report

At the completion of Software Simulation Testing, a Software Simulation Test Report shall be certified as complete by the accountable party and made available for Urban Utilities review and acceptance. Fully completed and signed off test sheets shall be included in the test report. Urban Utilities may request further inspection or witness testing to demonstrate punch list items have been closed out satisfactorily.

6.5.7 Control System Factory Acceptance Test (FAT)

The Control System FAT shall follow on from Software Simulation Testing by connecting controllers and field equipment together as closely as possible to the final installation to verify and validate the system as an integrated unit. This process shall be captured by formal testing documentation.

FAT shall use the actual RTU, PLC, communications devices, HMIs and SCADA hardware where possible and shall simulate field equipment and instruments not connected for testing. Switchboards and other electrical equipment shall be temporarily connected for this purpose. For demountable switchrooms, FAT shall be executed with equipment and inter-panel wiring permanently installed.

If SCADA changes are to be integrated into an existing SCADA system, temporary SCADA servers/clients shall be set up. Urban Utilities will not issue licenses for temporary hardware used.

No part of FAT will be allowed to take place on Urban Utilities sites. FAT shall be certified as complete and meeting the criteria by the accountable party before equipment is released for delivery to site.

Where Urban Utilities carries out spot checks on the tested equipment and/or test records and discovers anomalies or inconsistencies, the equipment shall be re-tested unless agreed otherwise.

FAT shall not commence until the Control System Software FAT Report is accepted by Urban Utilities.

6.5.7.1 Control System FAT Plan

A Control System FAT Plan in accordance with the Software Test Strategy (refer to Section 1.10.11 Software Test Strategy) shall be submitted for Urban Utilities acceptance prior to FAT. The plan shall enable validation and verification of functionality of the integrated system and outline test activities for RTUs, PLCs, HMIs,

SCADA and field equipment. FAT shall be comprehensive in order to minimise SAT requirements.

Control System FAT Plans shall incorporate requirements from the Software Simulation Test Plan and FAT plans for significant equipment (e.g. switchboards, variable speed drives, UPS etc.)

The FAT Plan shall include at minimum:

- Steps for preparation, configuration and start-up test equipment and equipment under test
- Tests covering complete system functionality as per the Functional Specification
- Checkbox columns including tester's initials and test date
- Multiple pieces of equipment with identical testing routines may have testing documented on a single checksheet applicable for all of them. Separate checksheets shall be provided for equipment with unique testing routines
- Where RTUs, PLCs, HMIs or SCADA are integrated into the project, testing documentation shall list alarm point, trend display and report functionality
- Setpoints, equipment settings and software and firmware revisions shall be recorded
- Point to point testing per cubicle (including control cubicles and load centres)
- Communication link testing between RTU/PLCs, SCADA, soft starters, VSDs, protection relays and all other devices with communication ports
- Radio communication link testing to remote devices. The Urban Utilities' test facility shall be used as required for testing remote SCADA networks.
- Test communication to all devices in the control system network
- I/O list
- HMI testing, including interface functionality testing and display of I/O values
- Hardware alarm tests
- Physical I/O tests
- Equipment SCADA point tests, including analog range and engineering unit confirmation
- Communication faults and RTU/PLC errors confirmed to alarm in SCADA
- Test all RTU/PLC local and remote I/O failure modes

6.5.7.2 RTU/PLC Hardware Testing

RTU/PLC hardware shall have the minimum inspection and testing tasks performed as follows:

- Confirm I/O card removal raises a hardware alarm in SCADA, a CPU LED indication and a hardware configuration software error
- Confirm hardware RTU/PLC time/date is updated as per the plant standard (e.g. from SCADA for STPs or locally for remote sites) and that the correct time zone is selected
- Confirm fieldbus equipment failure is enunciated on SCADA, programming, fieldbus software and (if applicable) CPU LED indication

- Verify no software failures are present in the diagnostic buffer or the engineering software
    - This shall be corroborated by Urban Utilities' commissioning engineer
- Verify non-volatile memory (e.g. initial values, setpoints) is retained on power failure
- Confirm CPU Battery Low alarm is raised to SCADA, local HMI and programming software
- Confirm detection, alarming and handling of loss of remote I/O racks
- Confirm systems are tested on the same software version used on site and no compatibility issues are caused (e.g. packet loss, unstable PID control or broadcast storms)
- Confirm LEDs and hardware displays are functional
- Inspect for visual damage (e.g. enclosures, electronics, pins, plugs, interface cables etc.)
- Conformal coating checks where required

6.5.7.3 Input / Output Functional Testing

I/O testing verifies operation of each analog channel, digital port and output relay and that values are scaled as expected within the RTU/PLC. Requirements are as follows:

- Control and power circuits shall be energised at operating voltage from a temporary supply
- Field pushbuttons, switches and indicating lights shall be temporarily installed, as required, to simulate field input and output devices
- Each feature shall be tested, including operation of actual field devices
- Where practical testing shall be carried out with instrumentation temporarily connected
- Motor starters shall be tested with a suitable temporary motor
- A parameter list shall be provided for each drive (both default and site-specific settings)

Analog checking shall include:

- Full range testing of all analogue signals (0%, 50% and 100% values recorded when injected with 4mA, 12mA and 20mA respectively)
- Over-range and under-range testing, except where there is a risk of equipment damage
- Confirm correct operation of controller setpoints and outputs, including process alarms
- Recording engineering units and mA values
- Recording testing method (e.g. current injection or transmitter simulation)

6.5.7.4 Control System FAT Notification

Urban Utilities shall be given written notice of the commencement of FAT. Notice period shall be as per prior written agreement or ten (10) working days.

Urban Utilities will not witness any testing until the Control System FAT plan has been accepted.

A schedule of daily testing activities shall be issued to demonstrate that all proposed tests can be executed in the time allocated.

6.5.7.5 Control System FAT Mark-ups

A set of master "As-Built" mark-up drawings shall be maintained throughout to record alterations or corrections made as a result of the FAT process.

Pass/Fail test records for physical wiring (e.g. point-to-point, control circuit functional tests) may be maintained as marked-up sets of schematic drawings with changes noted and elements (wires/circuits) highlighted as they are tested. Drawing sets for this purpose shall be clearly labelled (e.g. "point to point test drawing set" or "control circuit functional test drawing set").

Drawing sets shall be stamped, dated, signed and submitted with the Integrated FAT Report. Signatories shall be as follows:

Drawing Set	Signatory
Point to Point Test	Electrical Tester
Control Circuit Functional Test	Electrical Tester / Control Systems Engineer
Master "As-Built" Mark-ups	Control Systems Engineer

6.5.7.6 Control System FAT Report

At Control System FAT completion a Control System FAT Report shall be submitted for Urban Utilities review and acceptance. Equipment shall not be packaged or delivered to site prior to acceptance of the Control System FAT Report and all outstanding punch list items have been closed out. Urban Utilities may request further inspection or witness testing to demonstrate punch list items have been closed out satisfactorily.

The Control System FAT Report shall include signed-off versions of:

- Marked up "redlined" As Built drawings (as PDF and native versions)
- "Point to Point Test" and "Control Circuit Functional Test" marked-up drawing sets
- Switchboard compliance test sheets
- I/O list (signed to indicate HMI screen tests)
- HMI screen printouts (marked to indicate display animation and navigation control tests)
- SCADA Point list (each point initialled to indicate tested to the PLC)
- Certificate of Compliance for all electrical equipment
- IED protection setting parameter list (changes from defaults marked)
- VSD and soft starter protection setting parameter lists (changes from defaults marked)
- Evidence of:

- No PLC/RTU hardware faults
- Hardware alarms operational
- Memory & CPU usage as per Section 4.3.1 Hardware Configuration and Diagnostics

6.5.8 Site Acceptance Testing (SAT)

SAT is distinct to commissioning. SAT typically involves simulating all field equipment (at the field device) where practical to demonstrate functionality of the control system as per the Functional Specification. Commissioning occurs when the control system and other mechanical and electrical equipment are first introduced to the normal service conditions as an integrated system. SAT shall be completed prior to control system commissioning commencing.

Testing, pre-commissioning and commissioning shall be completed as per the accepted SAT documentation, including each site changeover commissioning plan, to Urban Utilities' satisfaction.

Control System Access Authorisation shall be obtained before accessing any live control system using form FOR646 *Access Authorisation for ICS Works*.

Site modification and testing works shall be performed under PRO396 *CSMS Change Management Procedure* and controlled using FOR603 *CSMS Change Management Form.*

Prior to SAT commencing the following shall be confirmed:

- Bench test simulation code has been removed
- I/O has been reinstated into the controlled copy of the tested code
- The system has been checked for diagnostics errors
- Code has been submitted to Urban Utilities for transfer to the site backup location
- Authorisation has been granted to make changes to existing control systems assets
- Change Request documentation has been accepted by Urban Utilities
- Permits, access, resources, tools and equipment required to undertake SAT are in place

Urban Utilities' sole responsibility concerning SAT itself shall be to witness tests. Urban Utilities may elect not to witness every test. SAT shall proceed in accordance with the accepted SAT plan and to Urban Utilities' satisfaction regardless of Urban Utilities' choice to witness tests.

6.5.8.1 Control System SAT Plan

A Control System SAT Plan shall be submitted to Urban Utilities for review and acceptance. The Control System SAT Plan shall define the sequence and testing structure for the complete installation (switchboard and field devices) in accordance

with the issued drawings/documentation and standard templates. This may include a Switchboard Changeover Commissioning Plan for brownfield sites.

SAT Plans shall include a test plan/strategy and associated blank set of checksheets.

SAT requires the actual control hardware, instrumentation and other electrical equipment to be installed and ready for testing. Field device simulation will be accepted only where a device cannot be observed to be functioning without simulation.

The SAT Plan shall incorporate the following as a minimum:

- SCADA testing of communication interfaces to all remote RTUs, PLCs and HMIs
- SCADA testing of communication interfaces to telemetry system where applicable
- SCADA testing for remote (i.e. offsite) network access
- Testing field instrument loops and status correctly displayed at SCADA terminals
- Device testing from the field to the Urban Utilities Telemetry Systems Control Room
- PLC hardware configuration and I/O checking
- Full redundancy and failover testing for PLCs, servers, networks and UPSs
- Recording of settings, setpoints and software and firmware revisions
- Completion of I/O Lists

SAT shall not commence until after Urban Utilities has accepted the SAT Plan, control system hardware and other equipment have been installed and equipment inspections are complete.

6.5.8.2 I/O Testing – Implementation and Test Plan

I/O shall be tested and recorded using test sheets clearly stating the point's verification method.

Operation of the field device shall be the primary method of proof. Exceptions to field device I/O operation shall be clearly stated in the test sheet including reasons for the exception.

I/O points shall be tested from field devices through to the RTU/PLC, local HMI and SCADA server.

I/O checksheets shall at minimum show the following parameters for all I/O points under test:

Parameter	Examples
RTU / PLC Number	PLC3
Rack Location	Sludge MCC
Rack Rack No.	0
Slot No.	8
Channel Number	1

Parameter	Examples
Card Type / Model	IC694MDL655CA
Brief Card Description	DI
I/O Address	255.255.255.255
Equipment ID	VLV01
Description	Equipment description and signal attribute (e.g. Plant Bypass Valve remote mode selected)
Tag Name	*VLV01dsRemoteSelected*
Drawing Number	486/5/5/0895-001
RTU/PLC Checks	Alarms. Analog raw & scaled values, filters and filter times
Local HMI Checks	Statuses, alarms, trends. Analog scaled value & engineering units
SCADA Checks	Statuses, alarms, trends. Analog scaled value & engineering units
Comments	

Digital I/O points under test shall include:

Parameter	Examples
Off State	Stopped
On State	Running

Analog I/O test sheets shall take the form individual instrument / device test sheets. Each analog signal shall be tested for the full range of operation. In addition to the minimum requirements for checksheets, Analog I/O checksheets shall include:

Parameter	Notes
Range - Out of Range (under)	Reading in engineering units at 0mA
Range - 0%	Increment reading in engineering units at 4mA
Range - 25%	Increment reading in engineering units at 8mA
Range - 50%	Increment reading in engineering units at 12mA
Range - 75%	Increment reading in engineering units at 16mA
Range - 100%	Increment reading in engineering units at 20mA
Range - Out of Range (over)	Increment reading in engineering units at 24mA
Instrument Local Reading	Scaled value & engineering units at each increment

6.5.8.3 Switchboard Changeover Commissioning Plan

Where an existing switchboard and associated control system equipment is being modified or replaced by new equipment, an individual Switchboard Changeover and Commissioning Plan shall be submitted for Urban Utilities review and acceptance. Switchboard Changeover and Commissioning Plans combine SAT and commissioning due to the condensed scheduling required.

Refer to TMS78 *Sample Typical Changeover Plan* for minimum details.

Site telemetry at unmanned sites, if installed, shall remain uninterrupted.

A flow strategy detailing the flow control and level alarming methodology during switchboard changeover shall be developed for each site. Note the following requirements:

- An independent, battery-backed, audible and visual level alarm to monitor wet well overflow shall be maintained throughout switchboard changeover
- Flow control shall be automatic and not rely on manual pump operation.

The Switchboard Changeover Commissioning Plan shall document the use of temporary power and pumping systems. At minimum, temporary pumping systems shall include:

- A generator
- At least two (2) pump starter units with automatic level control
- An independent, battery-backed audible and visual alarm

Switchboard changeover shall not commence until the Switchboard Changeover and Commissioning Plan has been accepted.

6.5.8.4 Equipment SAT Plans

The Control System SAT plan shall co-ordinate with SAT Plans for other equipment items (e.g. switchboards, motor staters, instruments etc.).

For complex projects, equipment SAT plans shall be provided for each equipment type in addition to the Control System SAT Plan. For smaller projects (e.g. new or refurbished pump stations) the equipment SAT plans and the Control system FAT Plan may be combined into a common document called the Integrated SAT Plan.

Equipment SAT Plans shall refer to the Control System SAT Plan. The Control System SAT Plan may require inclusion of further equipment testing over and above the equipment SAT Plans to cover any gaps in equipment testing or inspection.

6.5.8.5 SAT Report

At SAT completion, a SAT report shall be provided for Urban Utilities review and acceptance. The SAT Report shall contain all records of testing undertaken including completed ITPs, check sheets, records of instrument calibrations, test equipment calibration certificates. All test, inspection and check sheets shall be signed and dated by the testing officer. The name and electrical license number of the testing officer shall be provided on each sheet. The test records shall indicate the Urban Utilities equipment tag name for the instrument, cable or other device.

The SAT Report shall contain the following:

- Marked-up and updated “As-Built” electrical drawings (PDF and native versions) with the following marked:
    - Company Name
    - Company Electrical Licence No.

  - Electricians Name
  - Electricians Signature & Date
  - Electrician License No.
  - Site Supervisor Name & Accreditation (if any)
  - Full name of RPEQ (clearly printed)
  - RPEQ number
  - RPEQ signatory company name
  - RPEQ signature and date (PDF version only)
- Certificate(s) of Compliance and Testing as per the Electrical Safety Regulation 2013 (Queensland)
- Asset / Equipment Lists

The SAT report shall also contain outstanding punch list items identified during the SAT as being closed out to Urban Utilities' satisfaction. Urban Utilities may request further inspection or witness testing to demonstrate all punch list items have been closed out satisfactorily.

6.5.8.6 Failure

Any equipment that fails SAT or has defects shall be repaired or replaced. Inspections and tests invalidated by defects or rework shall be repeated.

6.5.9 Settings and Pre-commissioning

Settings of equipment and instruments shall be in accordance with equipment manufacturer instructions and with site specific data contained within the Project Documentation.

6.5.10 Commissioning

In addition to final commissioning of the completed control system, Works may include plant start-up assistance based on the scope in Project Documentation. All special tools, software and materials required for commissioning including calibrated test equipment, software and technical support from equipment suppliers shall be provided.

For new sites the commissioning of the control system and associated equipment shall not commence until the following have been completed:

- Equipment SAT is completed
- Control System SAT is completed,
- Equipment and Control System SAT Reports are accepted by Urban Utilities
- SAT Punch list items have been closed out as per Project requirements.
- Commissioning Plan is accepted by Urban Utilities

6.5.10.1 Commissioning Plan

A Commissioning Plan shall be prepared and submitted to Urban Utilities for acceptance prior to performing commissioning activities. Where an existing control system is to be replaced with a new system or components, the Commissioning Plan shall describe the procedure for cutover from the existing to the new control system. The plan shall demonstrate that all factors have been considered to ensure minimal disruption to the operation of the facility.

The Commissioning Plan shall detail:

- Pre-conditions, hazards, risks, risk control measures
- Contingency plans
- Task sequence and step-by-step procedures to be followed
- Maximum time that any process or monitoring device may be out of service
- Transition from existing RTU/PLC control to new (if applicable), including allowance for field measurement and control while neither are operational
- Transition from existing SCADA system to new (if applicable), including operating procedures while both systems are in use
- Rollback strategy in the event of a failure

Urban Utilities stakeholders shall be engaged early to determine control system operational modes, hazards, risks, control measures and other control system constraints.

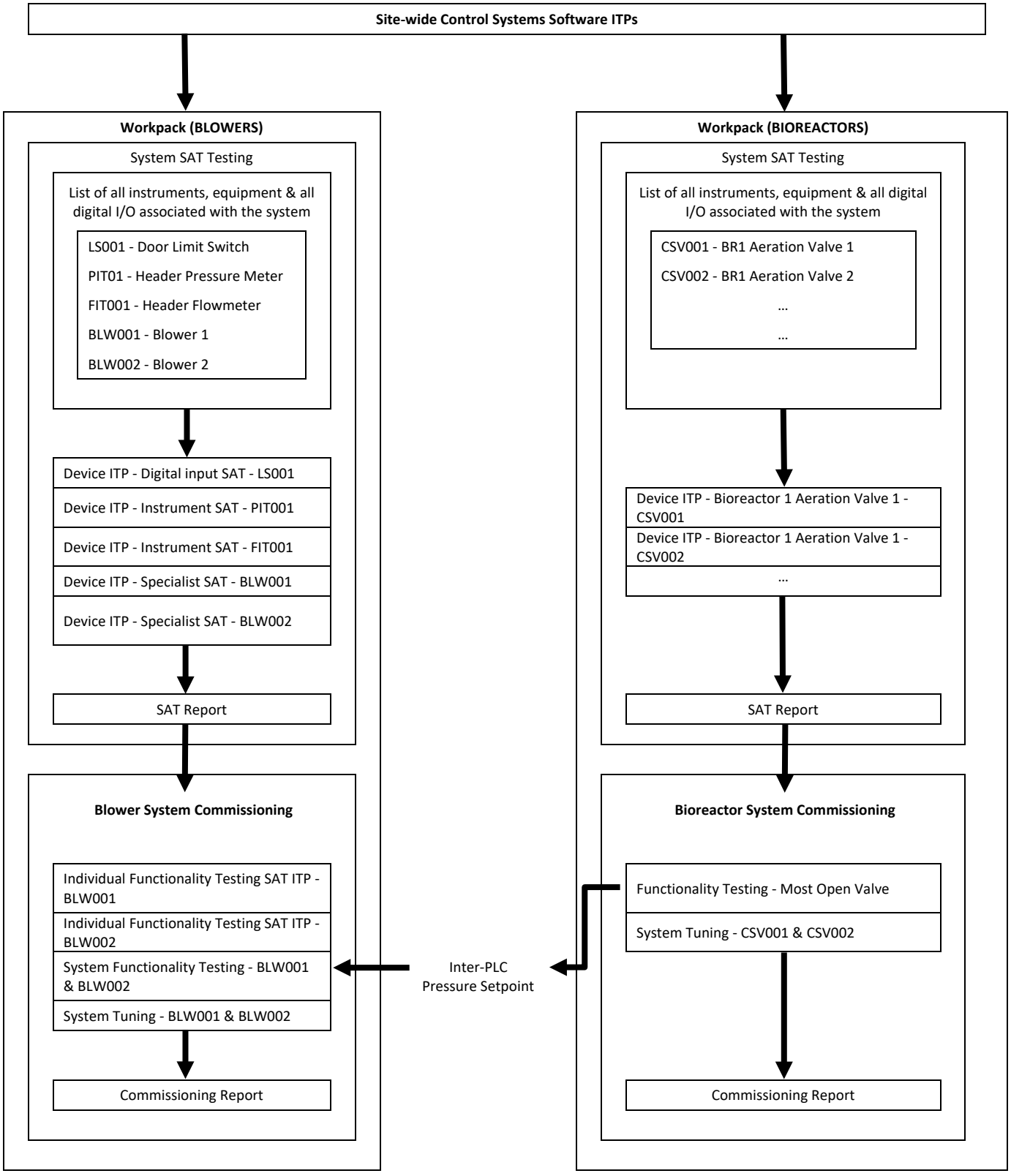
Device ITPs related to the system shall be completed as part of the SAT. Functionality testing shall only commence after all device ITPs have been completed and free from defect.

Commissioning Plans shall include a set of project-specific blank test and inspection test sheets. Test 'Pass' criteria shall be stated in full on supporting test sheets. Test results shall be fully traceable and replicable.

Commissioning Plans and ITPs for complex projects shall be subdivided into system or area-specific workpacks. Completed testing documentation shall be submitted in workpack form. Workpacks shall include:

- Associated digital I/O
- Associated instruments and devices
- Required inter-PLC data

The following workflow provides a typical control system workpack grouping:


Site-wide Control Systems Software ITPs
Workpack (BLOWERS)
System SAT Testing
List of all instruments, equipment & all digital I/O associated with the system
LS001 - Door Limit Switch
PIT01 - Header Pressure Meter
FIT001 - Header Flowmeter
BLW001 - Blower 1
BLW002 - Blower 2
Device ITP - Digital input SAT - LS001
Device ITP - Instrument SAT - PIT001
Device ITP - Instrument SAT - FIT001
Device ITP - Specialist SAT - BLW001
Device ITP - Specialist SAT - BLW002
SAT Report
Blower System Commissioning
Individual Functionality Testing SAT ITP - BLW001
Individual Functionality Testing SAT ITP - BLW002
System Functionality Testing - BLW001 & BLW002
System Tuning - BLW001 & BLW002
Commissioning Report
Workpack (BIOREACTORS)
System SAT Testing
List of all instruments, equipment & all digital I/O associated with the system
CSV001 - BR1 Aeration Valve 1
CSV002 - BR1 Aeration Valve 2
...
...
Device ITP - Bioreactor 1 Aeration Valve 1 - CSV001
Device ITP - Bioreactor 1 Aeration Valve 1 - CSV002
...
SAT Report
Bioreactor System Commissioning
Functionality Testing - Most Open Valve
System Tuning - CSV001 & CSV002
Commissioning Report
Inter-PLC Pressure Setpoint

6.5.10.2 Site Functional Testing

Full Site Functional Testing shall be performed with Urban Utilities witnessing.

Functional test results shall not be embedded within the Functional Specification.

Functional testing shall include, at minimum:

- Any functional testing not physically possible during FAT or SAT
- Equipment functionality testing (e.g. pumps, valves, fans etc.) under all modes of operation from both local HMI and SCADA terminals
- Functionality testing of the control system backup and changeover system
- Failure modes and process plant recovery
- Testing of alarms back to the Control Room
- Process control (automatic and manual operation)
- RTU/PLC programs and SCADA configuration shall be tested as per the Functional Specification and HMI User Interface Manual
- Black start tests to ensure black starts can occur with no nuisance alarms or callouts to operators
- Operational sequence and interlocking checks
- Testing of all control modes including backup and emergency control mode for pump stations

Departures from the Process Control Narrative and Functional Specification documents issued as Project Documentation shall be immediately brought to the attention of Urban Utilities. Urban Utilities approved changes to functionality shall be updated in the Process Control Narrative, Functional Specification, SAT Plan, Commissioning Plan and ITPs.

6.5.10.3 Commissioning Report

At the completion of the commissioning phase a final Commissioning Report shall be provided. The Commissioning Report shall compile all records generated during the commissioning works.

6.5.11 Proof of Performance Testing

6.5.11.1 Proof of Performance No. 1

Proof of Performance (POP) testing shall be undertaken at completion of commissioning for all equipment. Duration shall be as per prior written agreement, or fourteen (14) days if no such agreement exists. Performance during this period shall be analysed and a Performance Test report shall be prepared validating the system's functionality under normal (dry weather) process conditions. POP testing is not considered complete until equipment under test has operated continuously without defects for the full agreed duration.

6.5.11.2 Proof of Performance No. 2

Proof of Performance testing after a significant process or weather event shall be undertaken during the warranty period. The test period shall last until the system has returned to normal (dry weather) process conditions for 24 hours. The warranty period shall be as per prior written agreement or twelve (12) months if no such agreement exists. Performance during this period shall be analysed and a report shall be prepared validating the system's functionality under significant process or wet weather process conditions.

6.5.11.3 Proof of Performance Test Plan & Report

Proof of Performance Test Plans shall identify conditions and events under which proof of performance testing will be conducted and the performance standard to be achieved. Test plans for each test period may be submitted for Urban Utilities review separately or as a common document. Testing may not proceed without Urban Utilities' agreement.

Performance Test reports shall be submitted following each Proof of Performance period. Test reports shall include a summary of SCADA event lists, SCADA alarm lists and SCADA trends as well as a data-driven analysis of site performance during the test period. Issues discovered, including repetitive alarms/events, excessive cycling of motors/valves, low resolution of trend data, consequential alarming and process disturbances, shall be addressed as follows:

Test Period	Actions
Proof of Performance period No. 1	Remediate issues as they are discovered Remediate issues Repeat testing
Proof of Performance period No. 2	Propose a remediation strategy Remediate issues Repeat testing

6.6 Training and As-Built Documentation

Documentation shall be provided in accordance with Project Documentation requirements and the Deliverables Requirements List (DRL) included in Project Documentation.

As a minimum the following documentation shall be progressively maintained during the execution of the works:

- Quality Assurance records including ITPs and the associated check-sheets and test records for all elements of the works
- As-built mark-ups of all Project Documentation to reflect the completed installation
- A record of all Urban Utilities' accepted changes to Project Documentation
- A record of all Urban Utilities directives or Site Instructions
- A record of all submitted Requests for Information and associated Urban Utilities responses

- A record of all Urban Utilities accepted Design Deliverables

Note: Above documentation shall be maintained and available for Urban Utilities to inspect upon request.

Upon completion, the above listed documentation shall be officially submitted to Urban Utilities as well as a complete set of the final signed-off As-Built documentation.

6.6.1 Training

A comprehensive training course shall be provided for all systems included in the Works unless specified otherwise in the Project Documentation.

Training shall include two (2) off training sessions or as otherwise agreed with Urban Utilities. The training must be tailored to the intended audience (electricians, operators and engineers) and shall be conducted on-site or at an agreed location. A scheduled time for training shall be agreed with Urban Utilities.

The training course shall include but shall not necessarily be limited to the following:

- Introduction and overview of the system including a site walk through
- Description of the SCADA system including functions and features which shall be supplemented by the HMI user manual
- Description of RTU/PLC code structure & architecture
- RTU/PLC and SCADA fault finding guidelines
- Configuration and fault finding of instrumentation
- Preventative and corrective maintenance procedures
- Engineers and technicians shall be provided a comprehensive site walk-through and inspection, showing all the electrical and protection related equipment, the installation locations, methods of connection and practical live demonstration
- Engineers and technical staff shall require separate training to operators
- Where new proprietary or non-standard equipment has been introduced to Urban Utilities, a separate vendor-specific training course shall be provided. This course shall be onsite
- Training shall be competency-based
- Session plans, outcomes summaries and comprehensive course notes covering each topic shall be provided to accompany training sessions
    - Course notes shall be submitted for Urban Utilities review no less than ten (10) working days before the first session

6.6.2 As-Built Documentation

The following shall be stored and maintained up to date throughout the Works and made available for inspection by Urban Utilities upon request or continuously via a sharefile system:

- Quality Assurance records including ITPs, associated checksheets and test records for all control system hardware
- A master set of Project Documentation (e.g. drawings, documents, lists and schedules), marked-up to reflect the “As-Built” installation,
- A record of all Urban Utilities accepted changes to the Project Documentation

- A record of all Urban Utilities supplied directives or Site Instructions
- A record of Requests for Information and associated Urban Utilities responses
- A record of all design deliverables

Upon Works completion the above listed records shall be officially submitted to Urban Utilities.

The master set of Project Documentation and any amendments, including mark-ups, stamps and final signatures, shall be maintained in a purely digital format such as PDF, with changes and comments traceable to individual users in software. The following requirements apply:

- Master drawings and documents shall be updated as required
    - This may occur as RFIs or SIs are closed out, defects are corrected or at major milestones (e.g. FAT, SAT or commissioning completion)
- Drawings and documents shall be clearly and legibly marked "As-Built"
- Changes shall be marked up in RED
- Deletions shall be marked up in cross-hatched or highlighted BLUE
- The latest marked-up versions of Project Documentation shall be used during all site testing and commissioning checks
- Master drawings and documents shall be stamped, signed and dated prior to submission
    - An RPEQ of appropriate discipline shall certify the "As-Built" mark-ups
    - Final "As-Built" revisions shall visibly record the certifying RPEQ's initials and RPEQ number on the native file

6.6.2.1 As Built Drawings

Unless specified otherwise in Project Documentation the following CAD drawings shall be back-drafted to "As-Built" status and issued to Urban Utilities:

- Drawing Schedule
- Process and Instrumentation Diagrams
- Equipment location drawings (instruments and electrical equipment)
- General Arrangements (e.g. control system panels, marshalling panels and communications panels)
- Single Line Diagrams
- Schematics
- Termination Diagrams
- Cable Schedule
- Label Schedule
- Network Communications Architecture drawings (inclusive of communications racks, all individual FOBOT and network switch ports, all interconnection cables)
- Cable Block Diagrams
- Underground services and conduit route drawings
- Fire and Gas Detector location drawings
- Communication Architecture diagrams
- Block diagrams

- Package-plant related As-Built documentation inclusive of all "site-specific customisations" for all electrical and loop drawings, I/O lists and termination diagrams

6.6.2.2 As Built Documents

The following documents related to the control system shall be updated to "As-Built" status and issued to Urban Utilities:

- Process Control Narrative
- Functional Specification
- Control System Administration Manual
- HMI User Manuals
- Training Manual and Course Notes
- Package-plant related "As-Built" documentation including all site-specific customisation
- Interfaces, plant process narrative, functional specification, communication requirements, components listing and spares requirements

6.6.3 Final Commissioning, Testing and Inspection Reports

Finalised commissioning, acceptance testing and inspection and documentation shall be collated into final reports. The reports shall include all test results and shall be in PDF format with all inspection and testing sheets imported natively or scanned at minimum 600dpi resolution in colour and table of contents provided for quick reference in each document.

The following documents shall be provided by the Contractor:

- Equipment Inspection and Test Reports
- Instrument loop check sheets
- Software Simulation Test Report
- FAT Reports (equipment and control system report)
- SAT Reports (equipment and control system report)
- Commissioning Report (entire site)
- Electrical Certificate of Testing and Compliance (if applicable)
- OTDR Fibre cable test results
- Copper cable test records
- ProfiTrace test records and report
- Functional Test Records for all equipment
- IP Address Information for all devices

Handwritten field documentation shall be scanned in colour at high resolution and submitted to Urban Utilities as PDF files.

Final commissioning, testing and inspection reports shall be collated into a Testing and Commissioning Dossier to be handed over prior to Practical Completion.

Configuration settings shall be incorporated into the O&M manual master PDF file.

6.6.4 Software Configuration Files

At commissioning completion the following software configuration files and code shall be uploaded to an Urban Utilities Sharefile link:

- PLC/RTU Code and Configuration Files
- SCADA Projects, Configuration and Driver Files
- Local HMI Terminals Configuration Files
- Network Equipment Configuration Files (routers, network switches, modems etc)
- Protocol gateway converters Configuration Files
- VSD and motor protection relay Configuration Files (including internal logic files)
- Field bus instrumentation and device Management and Configuration Files and all device GSD/DTM/EDD files
- Configuration files for any other configurable device
- Programming software licences required to fault find and reconfigure devices

Hardware accessories required for configuration and fault finding shall be handed over alongside configuration files.

6.6.5 Operations and Maintenance Manuals

Operations and Maintenance (O&M) Manuals shall be provided for all electrical and control equipment, switchboards, switchrooms and installations. Manuals shall be separated into logical installation groups, such as by switchroom.

The minimum requirements of AS 1359, AS 2067, AS 2467 and AS/NZS 3000 for operation and maintenance manuals shall be met.

O&M manuals shall, where applicable, be provided in compliance with SEQ Water Supply and Sewerage Design & Construction Code (SEQ WS&S D&C Code) as well as the Urban Utilities addendum to the SEQ Code, PRO 395 *Urban Utilities Information Requirements*.

Each manual shall include a cover page with the following identifying information:

- Project name
- Asset Tag Name and Title
- Contract / Workpack / Program number and year of installation
- Company name, address & phone number

The following requirements apply:

- O&M manuals shall be presented as a single PDF file incorporating all components
    - PDFs shall not be password protected
    - PDFs, including OEM technical datasheets, shall be searchable
    - PDFs shall include a table of contents
    - PDFs shall be bookmarked by chapter
    - PDFs shall be readily printable or exportable by users without intervention
    - Mismatched portrait/landscape sheets and paper sizes shall be avoided
- O&M manuals shall preserve text and image quality
    - Original native files saved to PDF shall be used wherever possible

- Scans of printed documents available as a native PDFs will not be accepted
- Third party documentation (e.g. equipment manuals, datasheets & certificates) shall be the original PDF files from the vendor merged into the rest of the document
- Signature and approval pages shall use digital signatures wherever possible. If digital signatures are not available, a high-resolution (≥600dpi), OCR, colour scan of the signature page may be merged into the rest of the document
- Low resolution scans, copies of copies, faxes or otherwise degraded reproductions of documents are not acceptable.

A draft O&M manual shall be provided for review before practical completion, including all available information. Urban Utilities will review the documents and provide comments. Following final testing, commissioning and completion of As Built drawings the Contractor shall collate and submit the final O&M manual alongside the final Testing and Commissioning Dossier. Timings for draft and final deliverables shall be as per prior written agreement.

O&M Manuals shall include, at minimum:

- Narrative description of the installation and major equipment, by location and tag number
- Operating instructions for each item if equipment, including switchgear, protection relays and motor controllers
- Safety instructions
- Consolidated list of recommended maintenance and servicing schedules for all equipment in the installation
- Preventative maintenance instructions for switchgear in accordance with AS 2467
- Reference to detailed maintenance instructions for individual equipment in other manuals
- Drawing list showing number, title and revision
- Reference to single line diagrams
- Reference to protection line diagrams
- Reference to block diagrams
- Reference general arrangement and panel layouts
- Major equipment lists, cross referenced by tag number. Refer to the individual equipment manual for detailed part lists
- Consolidated list of all spare parts and consumables for the installation, including lubricants and insulation oils
- Details and names of major equipment suppliers
- Label lists
- References by Urban Utilities document number to all As Built drawings, documentation, configuration files, FAT and SAT test reports relevant to the installation and equipment described by that manual.
- For high voltage installations, the O&M manual shall also include a detailed description of the normal, emergency and maintenance procedures specific to the installation

Native files shall be handed over to Urban Utilities in addition to the master PDF file. Native files shall be in one of the following formats:

- Adobe Acrobat (*.pdf)
- Microsoft Word (*.doc or *.docx)
- Microsoft Excel (*.xls or *.xlsx)

6.6.5.1 Generic Manuals

Vendor generic manuals shall be provided with a searchable datasheet inserted into the PDF to indicate the actual equipment supplied. The searchable datasheet shall be inserted at the front of the manual.

6.6.5.2 Control System Administration Manual

A Control Systems Administration Manual shall be provided. This document shall include detailed technical description of the Control System and its communications architecture including network switch settings. The document shall allow Urban Utilities personnel to understand and maintain the control system.

The document shall be composed using Microsoft Office to allow future modification.

The Manual shall contain, at minimum:

Section	Requirements
List of References	• Process Control Narrative • Process flow diagrams (PFDs) and piping and instrument diagrams (P&IDs) • Functional Specification • Software Design Specification • PLC and SCADA Function Block Library specification (separate document or incorporated within the Software Design Specification) • Electrical drawings • Network architecture drawings • Electronic configuration and code files (PLC code, device configuration files) • Product manuals • Contact details of specialist maintenance contractors/vendors – personnel, company details, support hotlines.
Site Control System Overview	Describes the site control systems design, including standard control systems equipment, inter-connection between systems methods, protocols, engineering and diagnostic tools, etc. This section shall also reference the site architecture drawings and fibre cabling route drawings.

Section	Requirements
Hardware & Software File Lists	• A list of control systems software applications used by the RTU, PLC, Communications and SCADA system (e.g. server / client software, communication drivers, historian / reporting software, EWS applications) including support contact details, software versions, patches and license details. • A list of the IT hardware, operating system(s) and support software, including software used by operators and others on SCADA servers, clients and EWS (e.g. Windows, Linux, MS Office). This shall include hardware warranty details, contact numbers, software revisions, patches and license details. • A network hardware list for each separate control systems network, (e.g plant wide RTU/PLC to SCADA communication network, Profibus instrument network etc.) including device model, firmware version, complete device address and protocols. Lists shall include non-addressable, non-configurable and non-interrogatable devices, (e.g. signal repeaters, media converters, etc) • An RTU/PLC hardware list including each module, remote I/O, wireless modules, and non-configurable modules (e.g. battery packs)
Configuration Files	• List of control system equipment configuration files (e.g. PLCs, RTUs, network switches, routers, gateways, and converters, instruments, drives and other configurable devices) • Soft copies of configuration files described above • A list of protocol gateway & network device data mappings, setup parameters, firmware revisions, programming software (including revision) and instructions. Wiring diagrams shall be provided for non-standard interfacing cables.
Network	• Network utilisation, spare capacity, performance reports & loading calculations for networks (incl. additions to brownfield sites) • Instrumentation network protocol standard reports (e.g. ProfiTrace report for Profibus networks) • Network switch / router performance reports (e.g. average / peak bandwidth utilisation, packet errors, diagnostics etc.) • Where the network is designed with redundancy, the reports shall contain results of redundancy tests performed
Inter-PLC Communications	• Detail of inter-PLC or peer-to-peer communication transfer schemes and methods of communications, including hardware and protocols used • List of inter-PLC or peer-to-peer data mapping and the effect to the process of losing each signal, including mappings used in any protocol converters or other network devices

Section	Requirements
Operational Control for Maintenance Tasks	Detail of required process controls during maintenance tasks requiring interruption of control systems devices (e.g. stopping a PLC for firmware upgrade, isolating a local network switch for replacement etc.): • List of equipment affected by interruption • Required operator/technician actions to control process during interruption • Special start-up or shutdown procedures for control system device • Effects on the plant-wide system (e.g. peer to peer communications) • Alarm listings
Testing & Maintenance Schedule	List of required maintenance tasks and frequency of execution for control systems devices. (i.e. CPU batteries replacement, battery test etc)
Troubleshooting	Troubleshooting steps to faults that a maintenance control systems technician with basic control systems knowledge and process knowledge can follow and recover the system in a timely manner
Training Manual	The engineering control system training notes and manual shall be referenced or included in the document

APPENDIX A – ACRONYMS & ABBREVIATIONS

Term	Definition
AC	Alternating Current
ALARP	As Low as Reasonably Practical
DB	Distribution Board
DC	Direct Current
DRL	Deliverables Requirements List
ELV	Extra Low Voltage
EMC	Electromagnetic Compatibility
FIP	Fire Indicator Panel
FS	Functional Specification
IEC	International Electro-technical Commission
I/O	Input / Output
IP	Ingress Protection
ISO	International Standards Organisation
ITP	Inspection and Test Plan
LCS	Local Control Station
LV	Low Voltage
PCN	Process Control Narrative
PLC	Programmable Logic Controller
RFI	Radio Frequency Interference
RTU	Remote Telemetry Unit
SCADA	Supervisory Control and Data Acquisition
SDS	Software Design Specification
STP	Sewage Treatment Plant
UPS	Uninterruptible Power Supply
UV	Ultra-violet

APPENDIX B – REFERENCE DOCUMENTS

Document Number	Title
CA-17 c-h	Site Inspection Tests
FOR893	Instrument Schedule – Template
MP71	Electrical Safety Management Plan
MP183	Hazardous Areas Management Plan
PRO307	Procedure Drafting Guidelines – Contract Requirements
PRO363	WHS Hazard and Risk Management Procedure
PRO395	SEQ Water Supply and Sewerage- D&C Code Asset Information Urban Utilities Addendum
PRO450	Electrical Safety Standard Operating Procedure
PRO521	Safety in Design Standard Operating Procedure
PRO662	Safety in Design Guidelines
TEM336	Power System Analysis Guidelines
TEM514	Functional Specification Template for Complex Sites
TEM515	Sewerage Pump Station - Site Specific Functional Specification
TEM518	Hazardous Area Verification Dossier Template
TEM523	Cable Schedule Template
TEM587	Water Booster (MPC) – Site Specific Functional Specification Template
TEM588	PRV – Site Specific Functional Specification Template
TEM590	Water Booster (Lowara) - Site Specific Functional Specification Template
TEM591	Water Booster (VSD) - Site Specific Functional Specification Template
TEM592	Water Pump Station - Site Specific Functional Specification Template
TEM593	Reservoir - Site Specific Functional Specification Template
TEM596	Radio Network Desktop Design Report Template
TEM597	Radio Signal Site Survey Report Template
TEM598	Communications Network Design Report Template
TMS60	Low Voltage Switchboards and Enclosures Technical Specification
TMS62	Preferred Equipment List – Electrical and Instrumentation
TMS76	Corrosion Protection for Electrical and Mechanical Equipment and Structures
TMS78	Typical Switchboard Changeover Commissioning Plan
TMS117	Security, Access, Control and CCTV – Technical Specification
TMS200	PRV – Standard Functional Specification
TMS828	Standard Functional Specification Reservoir Sites

Document Number	Title
TMS1151	Preferred Equipment List – Control Systems
TMS1436	Safety in Design Report Requirements
TMS1631	Vacuum Pump Station – Standard Functional Specification
TMS1639	General Mechanical Works – Technical Specification
TMS1643	Water Booster Site (VSD) – Standard Functional Specification
TMS1645	Packaged Plant EI&C Requirements - Technical Specification
TMS1647	Equipment Tag Naming – Technical Specification
TMS1732	Electrical & Instrumentation General Specification
TMS1649	Standard MPC Water Booster – Functional Specification
TMS1650	Fixed Speed Sewage Pumping Station – Standard Functional Specification
TMS1654	Engineering Documentation Naming Requirements
TMS1706	Typical Water Pump Station - Functional specification
TMS1707	Siemens S7 PLC Library Specification
TMS1708	GE Fanuc PLC Library Specification
TMS1709	Rockwell Logix PLC Library Specification
TMS1710	Siemens TIA PLC Library Specification
TMS1712	STP Citect SCADA Administration Manual
WI58	Arc Flash Assessment and PPE Selection
WI140	Access to LV Electrical Equipment for Visual Inspection

APPENDIX C – TYPICAL DRAWINGS

The typical drawings and other documentation is provided for information only to demonstrate minimum content and layout of information and may not represent all the requirements specified in the Project Documentation.

Sewage Treatment Plants

Drawing Number	Title
QUU-STD-STP-00	Title Block
QUU-STD-STP-01	Legend
QUU-STD-STP-02	Power Flow Cable Block Diagram
QUU-STD-STP-03	Communication Network Architecture Diagram
Termination Diagrams	
QUU-STD-STP-60	Termination Diagram - PLC Layout Diagram (GE Fanuc)
QUU-STD-STP-61	Termination Diagram - Digital Input Card - 16PT (GE Fanuc)
QUU-STD-STP-62	Termination Diagram - Digital Input Card - 32PT (GE Fanuc)
QUU-STD-STP-63	Termination Diagram - Digital Input Card - 32PT (GE Fanuc)
QUU-STD-STP-64	Termination Diagram - Digital Output Card - 16PT (GE Fanuc)
QUU-STD-STP-65	Termination Diagram - Analog Input Card - 12PT (GE Fanuc)
QUU-STD-STP-66	Termination Diagram - Analog Output Card - 8PT (GE Fanuc)
QUU-STD-STP-70	Termination Diagram - Digital Input Card - 32PT (Siemens)
QUU-STD-STP-71	Termination Diagram - Digital Output Card - 16PT (Siemens)
QUU-STD-STP-72	Termination Diagram - Analog Input Card - 8PT (Siemens)
QUU-STD-STP-73	Termination Diagram - Analog Output Card - 8PT (Siemens)
QUU-STD-STP-74	Termination Diagram - DOL Starter
QUU-STD-STP-75	Termination Diagram - DOL Reversing Starter
QUU-STD-STP-76	Termination Diagram - VSD Starter 75 kW & Above
QUU-STD-STP-80	Termination Diagram - VSD Starter Under 75kW
QUU-STD-STP-81	Termination Diagram - Motorised Control Valve
QUU-STD-STP-82	Termination Diagram - Modulating Control Valve
QUU-STD-STP-83	Termination Diagram - PLC Layout Diagram (GE Fanuc)
QUU-STD-STP-84	Termination Diagram - Digital Input Card - 16PT (GE Fanuc)
QUU-STD-STP-85	Termination Diagram - Digital Input Card - 32PT (GE Fanuc)

Network Sites

Site Description	Electrical Drawings	Functional Specification	RTU Code
Trio Radio Repeater	√	NA	NA
Reservoir – Up to 2 off Reservoirs and Inlet Valves	√	√	√
Sewage Pump Station (Full option switchboard)	√	√	√
Sewage Pump Station (Reduced option switch board)	√	√	√
Sewage Pump Station (Low Risk switchboard)	√	√	√
Sewage Pump Station (Form 1 switchboard)	√	√	√
Vacuum Sewage Pump Station	√	√	√
Water Booster - Lowara	√	√	√
Water Booster - MPC	√	√	√
Water Booster - VSD	√	√	√
Water Monitoring Stations- PRV, FM, PG, Valves	√	√	√
Water Pump Station	√	√	√

√ - Available on request from Urban Utilities

NA – Not Available

APPENDIX D – CONTROL SYSTEM PROJECT DELIVERY

Activity	Conditions	Notes	References
Submit key control system design documents as per the DRL	Software code should not be commenced until key control system documents are accepted by Urban Utilities	Delivery Program must show initial issue dates and final issue dates for key documents: I/O List, Functional Specification, Software Design Specification, HMI User Interface Manual, Control System Equipment List, Overall Communications Architecture Drawing, Software Test Strategy	DRL
Order control system hardware and software licences	Hardware should not be ordered until control system key documents are accepted by Urban Utilities	Indicate long lead items in delivery program	
Submit Software Simulation Test Plan	Urban Utilities will nominate witness points in the Software Simulation Test Plan		
Execute the Software Simulation Test	Urban Utilities will not attend to witness any software testing until test plan is accepted		
Submit Control System FAT Plan and other Equipment FAT Plans	Urban Utilities will nominate witness points in the FAT Plans		
Execute the Control System FAT and other Electrical Equipment FAT (switchboards etc)	Urban Utilities will not attend to witness any testing until FAT Plans are accepted. The FAT requires temporary connection of all electrical equipment and SCADA equipment	Control System FAT must not commence until software simulation test report is accepted and punch list items discovered during software testing are accepted as closed by Urban Utilities	
Deliver Electrical Equipment and Control System Hardware to site	Equipment shall not be packaged and delivered to site until FAT Reports are accepted and ALL punch list items are accepted as closed by Urban Utilities		
Submit Control System SAT Plan and other Equipment SAT Plans	Urban Utilities will nominate witness points in the SAT Plans	Site specific Access Authorisation must be granted by Urban Utilities prior to site attendance. For software modification to existing sites approval of the change by Urban Utilities before any modification to installed software at the site can be undertaken.	FOR603 PRO396

Activity	Conditions	Notes	References
Execute the Control System SAT in conjunction with other Electrical Equipment SAT (switchboards etc)	Urban Utilities will not attend to witness any testing until SAT Plans are all accepted	Control System SAT must not commence until control system FAT Report is accepted by Urban Utilities and punch list items discovered during the FAT are accepted as closed by Urban Utilities	
Submit Site Commissioning Plan	Site commission cut-over plan and SAT plan are common document for refurbishment or replacement works at pump stations.		
Execute the Site Commissioning	Urban Utilities will be in attendance for all Commissioning activities	Site commissioning shall not commence until all SAT Reports are accepted by Urban Utilities and punch list items discovered during the SAT are accepted as closed by Urban Utilities.	
Submit Commissioning Report and all other documentation as per the DRL		Practical completion is when site commissioning is complete and the Commissioning Report is accepted by Urban Utilities. This includes the Control Systems Administration Manual.	
Submit Performance Test Plans No. 1 and No. 2			
Execute Performance Test No. 1	Test No. 1 must not be executed until performance test plan No. 1 is accepted by Urban Utilities and 7 days after commissioning report is accepted by Urban Utilities		
Execute Performance Test No. 2	Test No. 2 must not be executed until performance test plan No. 2 is accepted by Urban Utilities and 7 days after commissioning report is accepted by Urban Utilities		

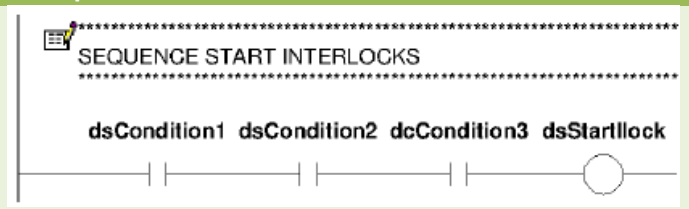
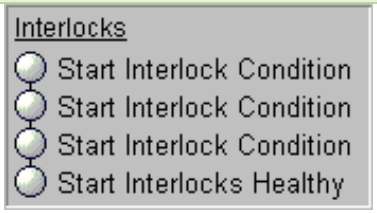
Activity	Conditions	Notes	References
Defect Liability Period	Critical, immediate impact faults are to be rectified with a Change Management form completed in retrospect. Otherwise, all defect remediation works are to be thoroughly investigated, planned and approved by Urban Utilities prior to rectification.	Site specific Access Authorisation must be granted prior to site attendance For software modification to existing sites all required documentation must be submitted to Urban Utilities and approved before any modification to installed software at the site can be undertaken.	

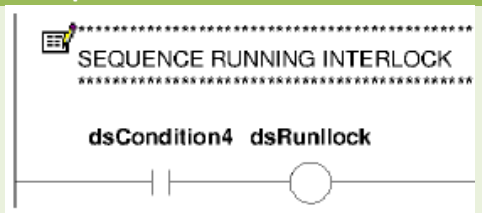
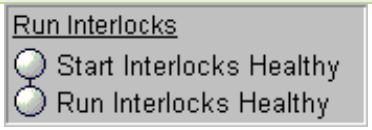
APPENDIX E – SEQUENCE EXAMPLE

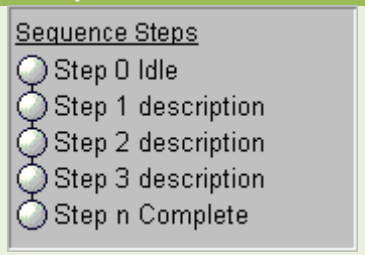
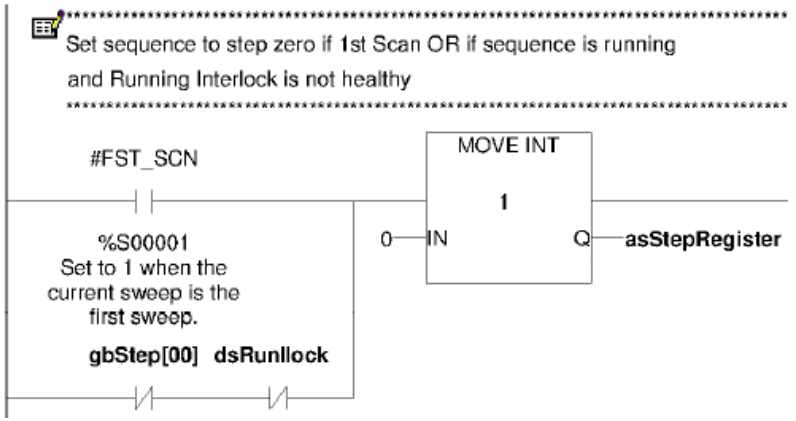
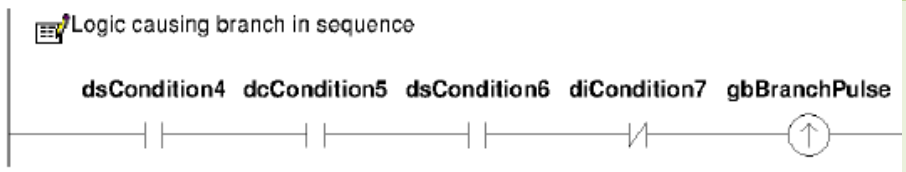
This is an example of a simple sequence, of acceptable form, written in ladder logic using a GE PLC interface.

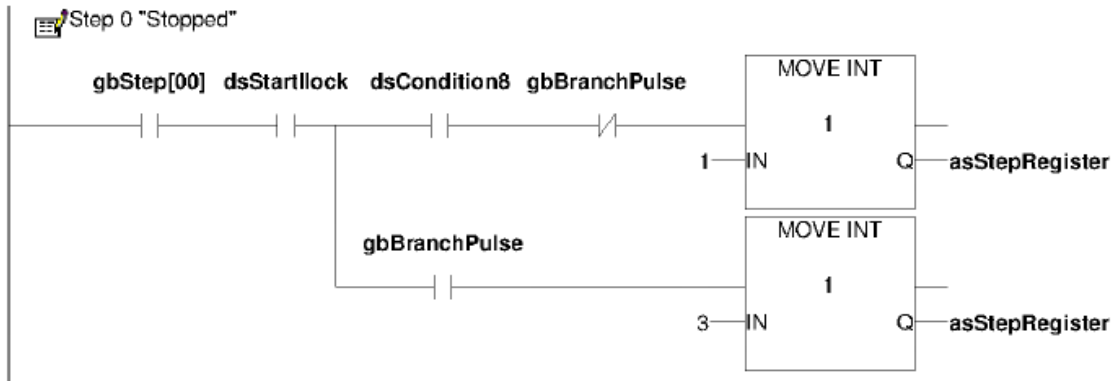
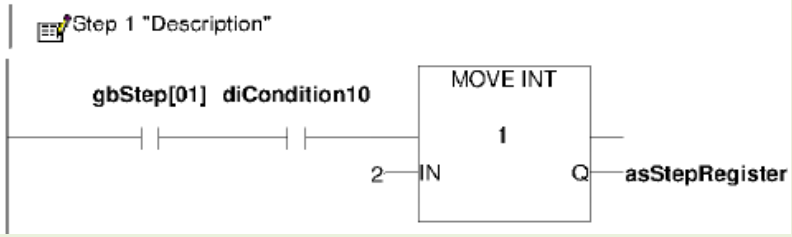
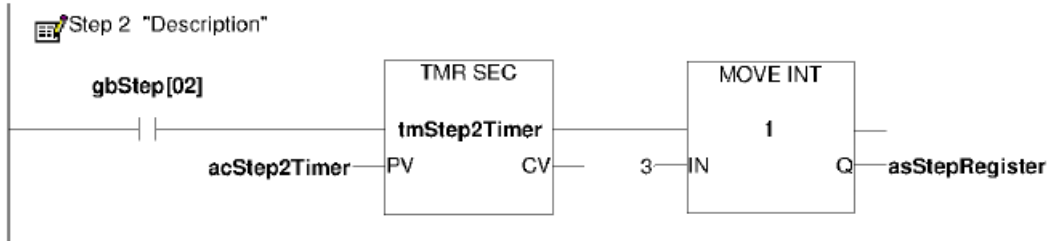
Examples of acceptable associated HMI indications are also shown.

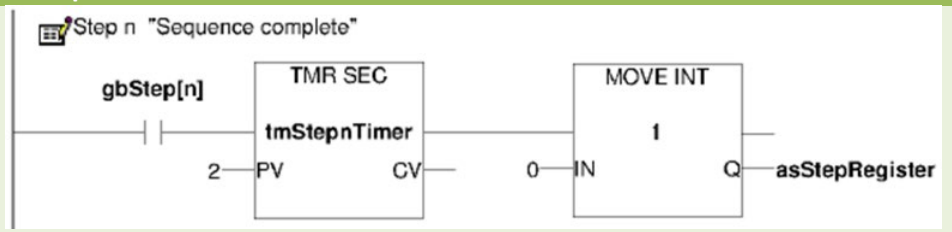
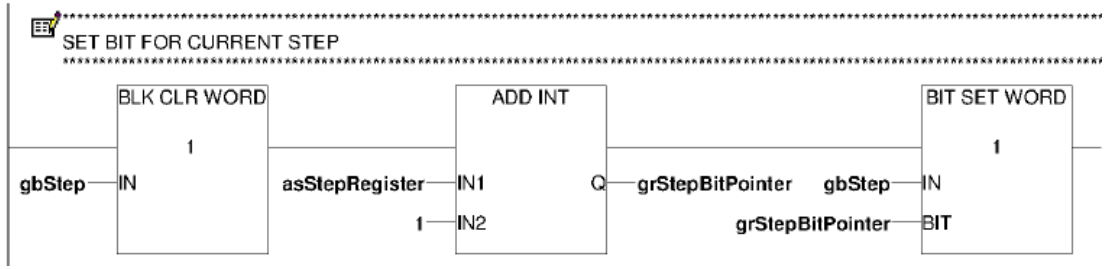
Each of the example conditions may be replaced by one or more conditions. If no real conditions are required then a system bit (*ALWAYS_ON* or *ALWAYS_OFF*) should be used.

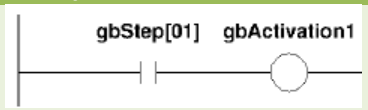
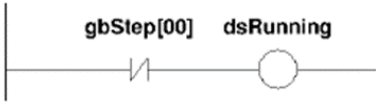
Step	Description	Example
1	Start Permissive	 Typical logic for Start Permissive conditions
	Interlock conditions as well as the resultant sequence start permissive, must be shown on the HMI	 Start Permissive conditions displayed on SCADA

Step	Description	Example
2	Running Permissive The start and running permissive may be identical in which case *dsCondition4* would be *dsStartIlock*.	 Typical logic for Run Permissive conditions
	Interlock conditions as well as the resultant sequence run permissive, must be shown on the SCADA	 Run Permissive conditions displayed on SCADA
3	Sequence Steps, Timers & Fault Handling The sequence should contain timers with user defined pre-set time to determine if a step is taking too long and when a step doesn't transition to next step. When a step transition fails, the sequence should safely transition to the shutdown part of the sequence or an idle step if applicable.	
4	Sequence Stopping and Pausing There should be an option for the operator to pause the sequence. The operator should have the ability do an Emergency or controlled shutdown of the sequence from all the steps.	

Step	Description	Example
5	Sequence Steps Sequence states as well as state permissive conditions must be shown on the HMI	 Sequence steps displayed on SCADA
6	Idle Step The idle state is to be adopted upon PLC startup, or when the sequence is active and the run interlock is lost.	 Typical logic for sequence idle step
7	Branching Logic This example shows a transition from step 0 to either step 1 or step 3.	 Typical branching logic

Step	Description	Example
	The branching logic must be implemented separately, to drive a state which is then tested by each branch.	 Typical logic for Sequence Stop step
8	State Transition This example shows a transition from step 1 to step 2 based upon a condition.	 Typical logic for Sequence Step 1
	The following example shows a timed transition from step 2 to step 3. Transition timers (except for those which are only for visual feedback) are critical process parameters, and must therefore be stored in non-volatile memory. These must also be settable by the operators.	 Typical logic for Sequence Step 2 active transition timer

Step	Description	Example
9	Last Step Step n to step 0. Once the sequence has transitioned to the completion state, it must transition back to the idle state. This example uses a 2 second timer before transitioning to the idle state.	 Typical logic for Sequence Step 'n' active transition timer
10	Sequence State Flags Each possible state number must also activate an associated unique digital flags. This example sets bits within a word to represent the current state.	 Logic sequence step active indication bit set

Step	Description	Example
11	Activations Where a sequence state drives the plant, the state flag must be used to drive clearly defined control activations, which must be utilised by the device control program blocks. These activations should provide separation from between the sequence and the device control meaning that changes required on either side of the activation would only require changes to the code in a single location. Step 1 Activations	 Sequence Step 1 indication to SCADA
12	Sequence Running Indication The Sequence Running indication shall be activated when the sequence is not in the idle state. The Sequence Fault indication could be driven by step duration timeouts or other relevant conditions.	 Sequence running rung