Control System Implementation

TMS1202

Standard Technical Specification

REVISION CONTROL

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1 INTRODUCTION

This specification details the minimum requirements for design, installation, testing and commissioning of PLC and SCADA control systems associated with Queensland Urban Utilities network assets. The SCADA systems are mostly existing systems and generally works will involve modification or expansion to the existing SCADA systems.

1.1 SCOPE

This specification shall be read in conjunction with the General and Specific Conditions of Contract. The Contractor shall be responsible for the supply of all labour, equipment, and materials, excluding any items specified as being supplied by QUU, necessary to deliver the works in accordance with the Project Documentation.

The Contractor shall be responsible for obtaining all necessary approvals, permits, licences and certificates required by Statutory Authority, Local Ordinances or other regulatory authorities covering scope of work.

1.2 DEFINITIONS

In this document, the following definitions apply:

Project Documentation	Governing technical documents for the specific item(s) for the specific works included or referenced in the Contract
Contractor	The entity bound (including sub-contractors appointed by the contractor) to execute the work having responsibility for design, manufacture and supply, installation, delivery, documentation and other functions as further defined in the documents related to the work.
Contract:	The agreement between QUU and the Contractor to which this specification pertains.
PLC	Any reference to the term PLC in this document shall apply equally to RTU's.

1.3 ACRONYMS AND ABBREVIATIONS

Term	Definition
BOM	Bill of Materials
CEMP	Construction Environmental Plan
DB	Distribution Board
DC	Direct Current
DP	Differential Pressure
ELV	Extra Low Voltage

Term	Definition
EMC	Electro-Magnetic Compatibility
EU	Engineering Units
EWS	Engineering Workstation
FBD	Function Block Diagram
FAT	Factory Acceptance Test
F&G	Fire and Gas
FIC	Field Installation Checksheets
HA	Hazardous Area
HSE	Health, Safety and Environment
HVAC	Heating Ventilation and Air Conditioning
IEC	International Electro-technical Commission
IED	Intelligent Electronic Device
IFC	Issued for Construction
I/O	Input / Output
ICT	Information and Communication Technology
IP	Ingress Protection
IS	Intrinsically Safe
ISO	International Standards Organisation
ITP	Inspection and Test Plan or Implementation and Test Plan
LCL	Lower Control Limit
LED	Light Emitting Diode
LV	Low Voltage
LCP	Local Control Panel
NC	Normally Closed
NO	Normally Open
MCC	Motor Control Centre
OT	Operational Technology (Control Systems)
O&M	Operation and Maintenance
PC	Personal Computers
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
QA	Quality Assurance
QUU	Queensland Urban Utilities
UCL	Upper Control Limit

Term	Definition
PC	Personal Computer
RFI	Radio Frequency Interference
RTU	Remote Telemetry Unit
SAT	Site Acceptance Test
SDRL	Supplier Data Requirements List
SPRI	Switchboard Pumpstation Reliability Improvement
STP	Sewerage Treatment Plant
SI	International System Units
SLD	Single Line Diagram
UPS	Uninterruptible Power Supply
UV	Ultra-violet

1.4 REFERENCE DOCUMENTS

Document Number	Title
PRO307	Procedure Drafting Guidelines – Contract Requirements
PRO395	SEQ Water Supply and Sewerage- D&C Code Asset Information QUU Addendum
	SEQ Water Supply and Sewerage Design & Construction Code (SEQ WS&S D&C Code)
PRO396	CSMS Change Management Procedure
PRO662	Safety in Design Procedure
SWMS2	Safe Work Method Statement Confined Space Entry
SWMS27	Electrical Testing - Safe Work Method Statement
TEM514	Function Specification Template for Complex Site
TEM515	Function Specification Template for Standard Site
TMS60	Low Voltage Switchboards - Technical Specifications
TMS62	Preferred Equipment List – Electrical and Instrumentation
TMS73	Operations and Maintence Manual Specification
TMS76	Corrosion Protection for Electrical and Mechanical Equipment and Structures
TMS78	Typical Switchboard Changeover Commissioning Plan
TMS849	CITECT SCADA Configuration Standard
TMS1151	Preferred Equipment List – Control Systems
TMS1186	HV Switchboards Specification
TMS1187	AC UPS Specification

Document Number	Title
TMS1200	Electrical Installation Specification
TMS1201	Instrumentation Installation Specification
TMS1203	General Requirements Hazardous Area Installation Specification
TMS1221	DC Power Supply Systems - Specification
TMS1222	Control Panel Specification
TMS1229	PLC Programming and Configuration Standard
TMS1406	LV Variable Speed Drives Specification
TMS1645	Package Plant EI&C - Technical specification
TMS1647	Plant and Equipment Tag Numbering - Technical Specification
TMS1648	EI&C Design Criteria – Technical Specification
TMS1651	Machine Safety Implementation – Technical Specification
TMS1654	Engineering Documentation Naming Requirments
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 Adminstrator Specification
WI58	Arc Flash Assessment and PPE Selection

2 STANDARDS & REGULATIONS

All 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 Codes, Standards or Regulations, the most onerous conditions of specification shall apply unless accepted otherwise in writing by QUU.

The Contractor shall not deviate from the provisions of the relevant standard without first obtaining agreement in writing from QUU.

Particular standards and regulations relevant to the work include but are not necessarily limited to the following:

2.1 AUSTRALIAN STANDARDS

The equipment shall be designed, manufactured and tested in accordance with the latest edition of all relevant Australian and International Standards, Codes and Regulations except where modified by this specification.

AS/ISO 1000	International System of Units (S.I.) and its Applications
AS 1020	Control of Undesirable Static Electricity
AS 1275	Metric Screw Threads for Fasteners
AS 1394	Safety Signs for the occupational environment
AS 1627.4	Metal Finishing – Preparation and Pre-treatment of Surfaces – Abrasive blast cleaning of steel
AS 1768	Lightning Protection
AS 1939	Classification of Degrees of Protection Provided by Enclosures for Electrical Equipment
AS 2700	Colour Standards for General Purposes
AS 2865	Safe Working in a Confined Space.
AS 3000	SAA Wiring Rules
AS 3008.1.1	Electrical Installations – Selection of Cables – Cables for Alternating Voltages up to and Including 0.6/1kV – Typical Australian installation Conditions
AS 3080	Telecommunications Installations Integrated Communications Cabling Systems for Commercial Premises
AS 4009	Software Reviews and Audits
AS 60529	Degrees of Protection Provided by Enclosures (IP Code)
AS 61000	Electromagnetic Compatibility (EMC)

2.2 INTERNATIONAL STANDARDS

ANSI/ISA-18.2-2009	Management of Alarm Systems for the Process Industries
BS OHSAS 18001	Occupational health and safety management systems
IEC 60050	International Electro-technical Vocabulary
IEC 61131	Standard For Programmable Controllers Part 1 General Information Part 2 Equipment and Test Requirements Part 3 Controller Programming Languages
IEC 61158-1:2014	Industrial communication networks - Fieldbus specifications - Part 1: Overview and guidance for the IEC 61158 and IEC 61784 series
ISO 9001	Quality Management Systems – Requirements
ISO 14001	Environmental Management Systems
IEEE Std 1815-2012	Standard for Electric Power Systems Communications – Distributed Network Protocol (DNP3)
IEEE 802.3-2018	IEEE Standard for Ethernet
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

2.3 INDUSTRY COMMUNICATION PROTOCOLS

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

2.4 REGULATIONS

The 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 Workplace Health and Safety Act 2011
- Queensland: Environmental Protection Act – 1994
    - Environmental Protection Regulation 2008
    - Environmental Protection (Air) Policy 2008

  - Environmental Protection (Noise) Policy 2008
  - Environmental Protection (Water) Policy 2008
- Australian Telecommunications Act 1997
- Australian Radiocommunications Act 1992
- ARPANSA Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz (2002)
- ACMA Radiocommunications (Analogue Speech (Angle Modulated) Equipment) Standard
- Building Code of Australia Volume 1 and 2
- Supply Authority Conditions of Supply and Consumer Metering
- Workplace Health and Safety Regulation 2011
  - Work Health and Safety (Codes of Practice) Notice 2011
- Electrical Safety Act 2002
  - Electrical Safety (Codes of Practice) Notice 2013
- Electrical Safety Regulations 2013
- Professional Engineers Act 2002

2.5 UNITS AND LANGUAGE

AS/ISO 1000 (metric SI system) shall be used. All documentation and correspondence shall be in the English language.

2.6 SUB-CONTRACTORS

The Contractor shall disclose, at the tender stage, all sub-contractors they intend to use as part of the contract works. The Contractor shall not sub-contract any work to any party without the prior written consent of QUU. It shall remain the Contractors' responsibility to audit and co-ordinate the performance of their sub-contractor with results being disclosed to QUU. All requirements applicable to the Contractor are applicable to their Sub-contractors.

2.7 CONTRACTOR EXCEPTIONS

The Contractor shall be responsible to submit, together with the Tender, a list of deviations or exceptions to this Specification. In the absence of any exceptions, it will be construed that the Contractor fully complies with this Specification.

2.8 ORDER OF PRECEDENCE

In the event of any conflict arising between this Specification and other documents listed herein, refer comments to QUU for clarification before the works commences. The order of precedence that applies is as follows:-

1. The Contract or Purchase Order Scope of Work
2. Project Data Sheets
3. This Specification

4. Project Drawings
5. Standards, Codes and Regulations

3 GENERAL REQUIREMENTS

3.1 OPERATION AND DESIGN LIFE

The control system hardware and software components shall be designed and installed for minimum life duration of 15 years continuous service in the environment and for the duty specified herein and in the relevant Project Documentation.

All control system hardware components shall be operated continuously 24 hours per day, 365 days per year under the climatic conditions detailed in this specification. All equipment shall be designed to perform this duty safely and without being attended.

3.2 LOCATION AND ENVIRONMENTAL CONDITIONS

Where electrical equipment is installed in a temperature controlled weatherproof room, the design environmental conditions shall be as specified on the Project Documentation. All instrumentation and associated equipment shall be designed and installed for the site conditions defined as follows:-

Location	South East Queensland	
Altitude	Above mean sea level.	0-300m
Ambient Temperature	Minimum	-5°C
	Maximum (dry bulb)	45°C
Relative Humidity	Minimum	26%
	Maximum	100% condensing
Solar Radiation	Black bulb design temperature - minimum mechanical design temperature for equipment exposed to solar radiation	85°C

Note: Corrosive environments are locations where H_2S gas or other corrosive chemicals and gasses can exist under normal operating conditions and can be both indoor and outdoor areas. This is applicable to all wet wells installations. All areas including inside air conditioned switch rooms at Sewerage Treatment Plants are considered corrosive environments. All materials installed shall be suitable for the environment.

3.3 UTILITY DATA

The electrical system may have the following voltage levels:

High Voltage Power Supply	33 kV AC, three phase 3 wire, 50 Hz, 11 kV AC three phase 3 wire 50 Hz, 6.6 kV AC, three phase 3 wire, 50 Hz

Low Voltage Supplies	3 ph, 4 Wire, 400 Volt +10,-6% 50 Hz ± 2%, MEN System Voltage Unbalance <5%
Single Phase Power Supplies	230 V AC, +10,-6%, 2 wire, 50Hz ± 2%,
Control Power Supplies:	UPS 230 V AC, single phase 2 wire, 50 Hz Regulated 24 V DC
Special Purpose Power Supplies:	Regulated 48VDC, 110VDC

The equipment shall be designed to operate continuously under the following conditions:-

- HV Distribution: Steady State Voltage ± 5% nominal voltage
- LV Distribution: Steady State Voltage +10,-6% nominal voltage
- Steady State Frequency ± 2.5% nominal frequency
- Transient Voltage ± 20% nominal voltage
- Transient Frequency ± 5% nominal frequency
- Total harmonic voltage distortion < 5 %

3.4 ELECTROMAGNETIC INTERFERENCE

All electrical and electronic equipment shall be CE marked as approved for commissioning in an industrial environment. The following directives apply to all equipment:

3.4.1 EMC Directive

The equipment shall be tested to meet Council Directive 89/ 336/ EEC Electromagnetic Compatibility (EMC) using a technical construction file and the following standards, in whole or in part:

- EN 50081- 2 EMC – Generic Emission Standard, Part 2 – Industrial Environment
- EN 50082- 2 EMC – Generic Immunity Standard, Part 2 – Industrial Environment

The equipment described in this specification shall be intended for use in an industrial environment.

3.4.2 Low Voltage Directive

All controllers shall also be designed to meet Council Directive 73/ 23/ EEC Low Voltage, by applying the safety requirements of EN 61131– 2 Programmable Controllers, Part 2 – Equipment Requirements and Tests.

3.5 SAFE WORK

All work in confined spaces shall be performed in accordance with the requirements of AS2865 Safe Working in a Confined Space and shall meet the minimum requirements as specified in SWMS2 Safe Work Method Statement Confined Space Entry.

The Contractor's operatives including its employees and sub-contractors and their operatives on site must be trained in confined space entry in accordance with the requirements of AS 2865 and SWMS2 Safe Work Method Statement Confined Space Entry.

Before commencing work on site, the Contractor shall assess the confined space entry requirements of the works and provide QUU with current certificates for confined space training of all its personnel who will be undertaking confined space entry

3.6 PERSONAL PROTECTIVE EQUIPMENT

The Contractor shall ensure all workers accessing live electrical equipment at voltages levels exceeding ELV shall comply with the minimum requirements of NFPA 70E:2015 or alternatively comply with WI58 Arc Flash Hazard Assessment and PPE Selection. Any departures from this work instruction or NFPA 70E:2015 shall only be permitted where accepted in writing by QUU.

3.7 WORKMANSHIP AND PERSONNEL

3.7.1 Installers

Personnel engaged in the installation of control system hardware components shall be accredited, suitably experienced, competent and skilled in the particular field of work in which they are engaged. All 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 the Queensland Electricity Board regulations.

All 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 that the Contractor's personnel are conversant with and comply with QUU's Safety Rules and Regulations, particularly those rules controlling the use of work permits.

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

3.7.2 Project Team

Prior to contract award the Contractor shall provide a description of the proposed software development team and their experience related to the requirements of the project. Each of the key personnel listed below shall have a brief career overview provided as part of the response and a detailed description of significant project experience and the current CV’s

- Project Manager responsible for control system integration
- Principal Programmer
- Programmer

- Site Supervisor during hardware installation

3.7.2.1 Principal Programmer

The Contractor shall nominate the Principal Programmer.

Where software works are on a scale that more than one programmer is required, the Principal Programmer shall supervise the other programmers and certify their work.

The Contractors' Principle Programmer must have:

- Electrical and control systems engineer qualifications acceptable to the Institute of Engineers Australia and be an electrical or control systems RPEQ.
- 10 years programming experience as a minimum.
- Demonstrated significant experience in programming.
- Previous experience in programming and development for, Water and Sewage Treatment Plants and Pumping Stations.
- Previous experience programming PLC's and HMI's using QUU's standard libraries, procedures and requirements will be highly regarded.

Previous experience with scopes of works for centralised management solutions or any points of OT/IT convergence will be highly regarded.

Contact details for Principal Programmers pre-approved by QUU will be provided upon request by the Contractor.

3.7.2.2 Programmer

Where programming work is to be performed by a resource that does not meet the Principal Programmer experience (as described above), their work must be supervised and approved by a Principal Programmer resource supplied by the Contractor.

The Contractor's programmer must have:

- 3 years programming experience minimum
- Demonstrated experience in programming.
- Previous experience in programming and development for Water and Sewage Treatment Plants and Pumping Stations.
- Previous experience programming PLC's and HMI's using QUU's standard libraries, procedures and requirements will be highly regarded.

Contact details for Programmers pre-approved by QUU will be provided upon request by the Contractor.

3.7.3 Previous Experience

Prior to Contract award the Contractor shall provide information on similar projects previously undertaken by the proposed project team. The reference projects must detail the following:

- Project name
- Client details
- Client reference contact name and details
- Detailed description of Contractor's involvement and responsibilities with the project
- Detailed description of project team members involvement and responsibilities with the project

3.8 INGRESS PROTECTION

All control system components shall have Ingress Protection (IP) rated as specified in the Project Documentation. All installation works shall be completed so as to ensure the ingress protection integrity of the equipment is maintained.

Control system hardware is generally located inside a switch room or a control room building. Switchrooms will be accessible by non-electrical personnel.

All control system components susceptible to damage or failure due to moisture or dust ingress shall be IP rated as follows unless specified otherwise:

- For outdoor installations - minimum IP56
- For indoor installations - minimum IP44

All outdoor equipment and installations shall be suitable for un-protected exposure to the weather, direct sunlight and hose-down cleaning. Where specified in the Project Documentation weather hoods and/or sun-shades shall be provided for UV and weather protection.

Contractor shall ensure adequate protection of equipment during storage, handling, installation and post installation phases with the following additional requirements.

The manufacturer's protective packaging shall be reinstated after inspection at site delivery and retained until the control system hardware is ready for installation at the site.

Control system hardware shall not be placed in a position that will allow foreign material such as sandblasting materials, metal shavings, paint spray, and rust scale to contaminate the enclosure or they shall be appropriately protected.

Electronic components shall be kept free from moisture and foreign matter. After installation the field control panel doors shall be kept closed to prevent moisture and foreign matter from entering the enclosure.

3.9 CONSTRUCTION DESIGN DOCUMENTATION

Design documentation shall capture the final element of design required to complete the control system installation and shall be completed by the Contractor. All such design works shall complement and not contradict or modify the intent of the design as provided in the Project Documentation.

All control system design documentation prepared by the Contractor shall be approved by an electrical RPEQ before submission to QUU for review at all stages of the project delivery. The design must be accepted by QUU prior to the procurement of equipment or commencement of equipment configuration and manufacturing works associated with the design.

The design shall provide a fit for purpose installation that ensures satisfactory operation of the control system and facilitates future inspection, maintenance and repairs.

For instances where not specified in the Project Documentation, the design documentation includes but is not limited to the following:

- Final equipment mounting location;
- Final equipment mounting arrangements and brackets;
- Equipment layouts in panels and on escutcheons;
- Panel and equipment access door opening clearances;
- Cable ladder and conduit/pipe sizing;
- Cable ladder and conduit/pipe routing;
- Underground cable trench cross-sectional layout and dimensions;
- Underground cable trench routing (including the coordination of these works);
- Cable ladder/tray and conduit support brackets;
- Building penetrations and sealing;
- Junction box selection and sizing;
- Equipment stands and sunshades;
- Label types and fixing methods for cables and equipment.

Control system construction design documentation shall comprise the provision of suitable sketches, schedules and descriptive information clearly identifying the information required for review.

3.10 USE OF CORRECT TOOLS

All equipment and tools to be utilised in the control system site works shall be safe, suitable for the task and in good working order. In all instances tools and equipment shall be selected to maximise safety of equipment and personnel during the execution of the works as well as providing a quality installation.

All tools and appliances furnished with installed equipment shall be maintained in good condition and handed over to QUU on completion of the works.

3.11 SETTING OUT WORKS

The Project Documentation will include installation locations for the control system hardware. For instances where the exact location is not clearly defined in the Project Documentation the Contractor shall site assess the area to confirm the best location.

Following this assessment the Contractor shall submit a proposed exact installation location to QUU for acceptance.

Installation locations shall take into consideration the following:

- Relevant regulations, codes and standards;
- Accessibility of equipment for routine inspection and maintenance tasks;
- Safe access for personnel;
- Clashes with other services, plant and structures;
- Suitability for equipment to perform intended function;
- Appearance;
- Not to impede walkways and access to equipment;
- Not to impede maintenance works on nearby plant;
- Not to expose equipment to higher than normal risk of damage (vibration, material spillage, wet areas etc);
- The design intent of the Project Documentation.

3.12 MOUNTING

All control system components shall be installed strictly in accordance with the manufacturer's instructions and the relevant Project Documentation. Where such instructions are not available, details of the proposed installation method must be accepted by QUU prior to commencement of the works.

3.13 CARE AND MAINTENANCE

The Contractor shall ensure the system is installed and configured such that it is easily maintained with minimal disruption to operations. Consideration should be made to maintain system availability during the following activities:

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

The Contractor shall ensure that all personnel within their control are fully aware of and comply with the requirements for good housekeeping on the site.

For all installation activities safe house-keeping procedures shall be utilised for managing the necessary tools, equipment and accumulated rubbish so as to ensure a safe working environment for all personnel executing and in the vicinity of the works.

All plant areas shall be kept free of cut cable ends, cable strippings and other accumulation of rubbish. Rubbish in these areas shall be collected and disposed of in accordance with the approved site procedure on a daily basis. Materials and equipment required for immediate use only shall be stored within these particular areas.

All 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, swart, grit blasting etc. Where flame cutting or welding is being undertaken fire blankets shall be used to protect all electrical equipment and materials. Cable gland plates provided with equipment shall not be drilled in-situ, but shall be removed to preclude the risk of drilling debris entering the associated equipment.

All equipment not being actively worked on shall have all doors closed and all covers and gland plates firmly in position to prevent rubbish, dust and moisture entering the equipment.

Tools and loose items shall not be left or stored inside control panel enclosures.

After completion of the terminations to any control panel or item of equipment, such equipment shall be thoroughly cleaned out using suction cleaners and all dust and rubbish removed.

4 HARDWARE

4.1 SUPPLY

Control system hardware components supplied by the Contractor shall include but not be limited to items specifically identified in the Project Documentation. A list of construction materials to be supplied by the Contractor shall be submitted by the Contractor to QUU for approval prior to placement of any orders. Equipment quantities shall be determined from the Project Documentation. All materials shall be new and unused, free of defects and shall be supplied with relevant certification and documentation.

QUU will supply the control system components defined in the Project Documentation as being supplied by QUU. The Contractor shall supply all other components and equipment necessary to make a complete and fully functional installation in accordance with the Project Documentation and the Contractor's design documentation. It shall be the Contractor's responsibility to define all Contractor supplied materials and equipment and to ensure the timely ordering and delivery of such to site so as to not impact on the construction schedule.

All Contractor supplied items shall be of manufacturer, type and model as specified in the Project Documentation. For all non-specified equipment the TMS62 Preferred Equipment List – Electrical and Instrumentation and TMS1151 Preferred Equipment List – Control Systems shall nominate the preferred suppliers and/or equipment.

All equipment installed in corrosive environments shall have conformal coating which specifically includes protection against Hydrogen Sulphide (H_2S) gas. The Contractor shall not deviate from these requirements without prior written acceptance from QUU. Where the materials are not specified the Contractor may offer standard materials suitable for the application, environment and operating conditions. Non-specified equipment shall be of the same type, grade and quality as similar items specified in the Project Documentation. Corresponding parts of similar equipment shall where possible be interchangeable.

The Contractor shall maintain up-to-date inventory list of all items and consumable and procure additional materials as required well in advance so as not to delay the schedule due to shortage of materials.

All control system components shall be of standard manufacture and readily available from suppliers unless specified otherwise in the Project Documentation. All equipment supplied shall be sourced from local OEM (Original Equipment Manufacturer) Authorised Distributors within Australia. On request, the Contractor shall provide full traceability of the equipment supply chain. The supplied BOM shall include serial numbers with part numbers.

The selected equipment shall be suitably rated for the application with particular attention given to the following:

- Process conditions
- Power rating
- Voltage rating
- Frequency rating
- Duty rating

- IP rating
- Hazardous Area certification

All components and materials shall be new and comply with the relevant specifications, regulations, codes and standards.

All communications equipment shall comply with the relevant Telecommunications Acts, Australian Standards and Communications agencies i.e. ARPANSA, ACMA etc.

All control system components and materials shall be free from:

- Asbestos
- Ceramic fibre
- Chlorofluorocarbons
- Polychlorobiphenyls (PCB) and their isomers
- Radioactive materials(unless specified in the Project Documentation)
- Mercury

Any dangerous goods shall be labelled and identified in accordance with the project requirements. All hazardous materials shall be supplied with a material safety data sheet (MSDS).

4.2 HANDLING AND STORAGE

All control system hardware equipment shall be stored, handled and preserved in accordance with the relevant Project Documentation.

The Project Documentation will define all equipment items to be received and stored by the Contractor. All such equipment shall be immediately inspected by the Contractor upon receipt for damage sustained during transit. Any damage shall be notified in writing to QUU and suitable action agreed with QUU to minimise any work schedule delays.

The Contractor shall be responsible for the safety, security and preservation of all equipment received for the duration of the Contract. All such 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. As a minimum the following shall be provided for storage locations of control system hardware equipment:-

- Lockable fenced all weather compound;
- Adequate lighting for security and safe access;
- All weather hardstand surface;
- Suitable all weather vehicle access.

Storage locations for equipment that are susceptible to deterioration from the outdoor environment shall further comply with the following:

- shaded, dry, weather protected area;
- ambient temperatures within the range of 5°C to 45°C;

- humidity not more than 95%.

Storage locations for equipment designed for indoor installation shall further comply with the following:

- air conditioned;
- temperature controlled;
- dust free.

Any equipment damaged or misplaced during storage by the Contractor shall be immediately brought to the attention of QUU, to advise suitable action to minimise any potential impact on the construction schedule.

The Contractor shall be responsible for continuous monitoring and reporting of all equipment stored by the Contractor. Adequate levels of Contractor supplied materials shall be maintained at all times to ensure that the installation schedule is not delayed due to material shortages. Similarly, the Contractor shall advise QUU of any possible future shortages in QUU supplied materials to ensure replacement stocks can be ordered and delivered without impacting on the installation schedule.

4.3 EQUIPMENT PRESERVATION AND PROTECTION

Control system hardware equipment shall not be left unprotected on the construction site, the equipment shall remain in storage until is ready to be installed. All accessories shall be stored with the equipment to which the accessories are associated.

Cables used in the installation of control system hardware shall be stored above ground level, protected from mechanical damage and all unused cables shall be fitted with end boots to protect against moisture ingress to the cable.

Control panels and other equipment installed in exposed external areas shall be protected until handed over to QUU. During installation temporary provisions shall be made to protect equipment from any damage, or deterioration, which may be caused by exposure to the environment. Additional temporary protection shall be provided when necessary to guard against adverse conditions which may arise.

Control system hardware for installation in enclosed areas shall not be exposed to the external environment at any time after unpacking. If necessary, during installation temporary air-conditioning shall be erected in accordance with supplier's preservation requirements.

Adequate protection shall be provided for installed equipment to prevent damage from work in progress in the same or adjacent areas. All covers, caps, weather protection, etc., shall be replaced at the end of each working day.

Extreme care shall be exercised in the protection of equipment against mechanical damage during the course of installation.

All equipment shall be protected against the ingress of moisture, dust, dirt, rodents, birds, insects and foreign bodies during and after installation.

Care shall be taken to protect finished, painted surfaces.

4.4 SURPLUS AND SCRAP MATERIALS

Any surplus materials shall remain the property of QUU and throughout the works shall be collated, sorted and delivered to the locations as advised by QUU.

Any scrap materials shall remain the property of QUU and throughout the works shall be handled in accordance with the project procedures or as agreed with QUU.

All waste materials shall be disposed of in accordance with the Contractor's approved CEMP.

4.5 MATERIALS RECEIPT INSPECTION

All control system hardware 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 prepared by the Contractor that details the exact inspection requirements.

The Contractor shall visually inspect the equipment upon receipt for damage and for conformance to the specifications and purchase requisition(s). Any damage to the equipment or deviation from the specifications or requisitions, including but not limited to, nameplate data, dimensions, accessories, shall be noted and reported immediately to QUU and to the party responsible for the equipment procurement.

No action shall be taken to repair, replace or modify non-conforming materials without QUU acceptance.

All identification tags shall be left securely attached to the equipment and shall not be removed during installation.

5 EQUIPMENT INSTALLATION

5.1 GENERAL

Control system hardware equipment shall be installed in accordance with the standard installation documentation unless otherwise approved by QUU. For any equipment that has not been defined in the Project Documentation, the Contractor shall design and submit a proposed installation arrangement to QUU for approval. No procurement, fabrication or installation shall commence without the receipt of acceptance of the design by QUU.

The Contractor shall ensure that the equipment manufacturer's installation recommendations are available and reviewed prior to the commencement of any installation works. All manufacturer installation recommendations shall be strictly followed. Any conflict between the standard installation documentation and the manufacturer's recommendations shall be brought to the attention of QUU for resolution. Unless otherwise specified in the Project Documentation, all brackets and fixings provided by the equipment manufacturer shall be installed.

A sufficient number of brackets, supports and fixings shall be provided to solidly mount or fix the equipment in position without imposing excessive strain on the equipment or mountings.

All equipment with cable entries shall be arranged so that cabling is bottom entry unless otherwise specified in the Project Documentation.

5.2 LOCATION

Control system hardware equipment shall be located to facilitate ease of operation, inspection and maintenance. The equipment locations shall be in the approximate positions shown on layout and general arrangement drawings. The Contractor shall determine the final position based on the approximate position. Consultation over the final positioning of equipment if a conflict arises shall be agreed with QUU.

5.3 ERGONOMICS

Due consideration shall be given to the following:

- Positioning of equipment does not constitute a safety hazard.
- Equipment does not conflict with any existing or proposed underground services.
- Visibility and accessibility for both maintenance and operations purposes, in particular status lamps, communication ports and configuration selector switches shall be accessible from the front of the equipment.
- All equipment shall be free from vibration.
- The location of control systems components shall not require drainage of any tank or holding facility to access.
- All equipment shall be accessible from fixed platforms or landing.

5.4 MOUNTING OF EQUIPMENT

All equipment and accessories shall be installed according to the drawings and information provided and in the Project Documentation. Written acceptance shall be obtained from QUU before implementing any deviation from accepted design drawings and documentation.

Non galvanised members where specified in Project Documentation shall be painted after fabrication in accordance with TMS76 Corrosion Protection for Electrical and Mechanical Equipment and Structures Technical Specification. The Contractor may nominate alternative paint systems, however will only be accepted by QUU where considered equivalent or superior specification to TMS76. The Contractor must obtain written acceptance from QUU for any alternative paint systems proposed.

Wherever possible, equipment shall be located so that they are protected from damage by passing or falling objects.

Wherever possible, equipment shall not be exposed to dripping process materials. Where this is unavoidable, a suitable cover shall be placed over them. The location shall not be susceptible to a rise in water or sewer levels. All instruments shall be positioned to remain fully functional and within their programmed range and for all rises in water or sewer levels. Equipment shall not be installed on walkways and safety routes so as to obstruct personnel movement.

Throughout the construction period, equipment shall be adequately protected from the environment by covering with plastic sheet.

Equipment installed in areas where exposed to direct sunlight and rain shall be protected using sunshades. Sun shades shall be easily removable (not requiring demounting of the instrument) to facilitate maintenance. The sun shade enclosures shall have at least 100mm clearance around the instrument transmitter. The sides and top shall protrude at least 100mm in front of the equipment enclosure.

Equipment mounting location shall also consider protection from sources of H_2S gas and protection from vermin and bird damage.

5.5 REMOVAL AND DECOMMISSIONED OF EQUIPMENT

Any surplus or decommissioned equipment shall remain the property of QUU and throughout the works and the Contractor shall collate, sort and deliver the items to locations as advised by QUU.

The Contractor shall be responsible for the safe and effective removal and off-site disposal of all decommissioned cables and conduits, waste plant and miscellaneous equipment in accordance with all current legislation and local, regional and state/national statutory requirements.

5.6 EQUIPMENT ITEMS

The Contractor shall ensure all control system equipment is selected from TMS1151 Preferred Equipment List - Control System unless otherwise specified in the Project Documentation.

Where an item of equipment is not specified or is unavailable the Contractor shall submit an alternative equipment list with quantities and data sheets and/or other available technical information for QUU acceptance.

5.6.1 Control Panels

Refer TMS1222 Control Panel Technical Specification

5.6.2 Communications Panels

Refer TMS1222 Control Panel Technical Specification

5.6.3 SCADA and HMIs

5.6.3.1 Local HMI Terminals

Refer TMS1222 Control Panel Technical Specification and TMS1151 Preferred Equipment List – Control Systems for local HMI terminal requirements.

A local HMI terminal shall not be used as a substitute where a SCADA Client workstation is required. QUU will accept a local HMI terminal for control and monitoring of equipment contained within switchboards in place of physical pushbuttons, meters and switches.

The functionality of the local HMI supplied with packaged plant and vendor proprietary systems shall be replicated on the QUU SCADA system.

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

The site specific SCADA HMI terminal colour convention shall be applied to the local HMI and all equipment statuses on the local HMI shall also include wording as status confirmation. Status wording includes, ‘Running’, ‘Stopped’, ‘Ready’ and ‘Fault’.

5.6.3.2 SCADA Client Workstations

SCADA client workstations are generally not installed at Network sites with the exception of SP010 EFPS.

Where a SCADA client workstations is required, refer TMS1151 Preferred Equipment List– Control Systems for SCADA client workstations accepted by QUU and which are typically desk mounted workstations running Microsoft Windows operating system.

The Contractor shall provide SCADA client workstations and all required monitors, cables, KVMs, keyboards and mouse for STP control rooms. Refer to Appendix B for typical number of SCADA Clients, monitors and licenses at different STP sites.

The implementation of panel mounted PC SCADA Client workstation touch screens shall require acceptance by QUU and is not preferred and should only be used in space constrained areas.

Symantec End Point protection anti-virus software shall be installed on the client workstation.

5.6.3.3 SCADA Servers

SCADA servers are generally not installed at Network sites with the exception of SP010 EFPS. Each network site will connect into an existing centralised SCADA system.

Where a SCADA server is required, refer TMS1151 Preferred Equipment List – Control Systems for SCADA servers accepted by QUU.

The Contractor shall provide two SCADA servers for new STP site installations. The servers shall be configured by the Contractor using the VMWare virtual environment.

Redundant alarm paging hardware and software license shall be procured and installed on each servers by the Contractor for new STPs.

Symantec End Point protection anti-virus software shall be supplied and installed on new servers by the Contractor.

Servers shall be rack mounted and secured in a lockable RU communications panel. Access to the servers shall require a key. The communications panel location shall be in an air-conditioned room with restricted and secure access. Physical distance and separation of the servers from the plant production areas is preferred, however will be site dependant. Communications panels and all equipment contained within shall be fed from a UPS supply.

The WAN connection to STP servers will be performed by QUU personnel.

5.6.3.4 Engineering Workstations

SCADA engineering workstations are generally not installed at Network sites with the exception of SP010 EFPS.

Where a SCADA engineering workstation is required, refer TMS1151 Preferred Equipment List – Control Systems for engineering workstations (EWS) accepted by QUU.

A separate EWS shall be supplied and installed by the Contractor for new STP's unless specified otherwise in the Project Documentation. The Contractor shall supply and install all engineering software onto a separate virtual machine (VM) on the secondary server, where it is specified that a separate EWS is not required.

All engineering licenses shall be supplied and installed by the Contractor unless otherwise specified in the Project Documentation. All engineering software shall be installed on the virtual machine (VM) platform. The default for the VM shall be VMware Workstation Pro unless specified otherwise by QUU

Symantec End Point protection anti-virus software shall be supplied and installed by the Contractor on the EWS.

The EWS shall be located in a physically secure and air-conditioned room. The EWS shall not be accessible or visible to control room visitors. The EWS shall be ready to patch into the QUU WAN connection from the installed location.

The EWS power shall be supplied from a UPS.

5.6.4 Cables

Cables shall be installed in accordance to the relevant sections of TMS1200 Electrical Equipment Installation Specification and the Cable Schedule for the project.

Cables shall be run on cable ladders for all main routes as per relevant cable routing schedule. The location of cable ladders shall not obstruct walkways, escape routes or access to plant or equipment that may require regular access. In all cases, except where agreed, instrumentation and control cabling shall be run on cable ladder. The cable shall be mechanically protected throughout its entire route and shall be installed in conduit where it transitions from cable ladders to the final point of termination.

In routing of control and instrument cables, care shall be taken to maintain the cables segregated and separated from motors or other electrical devices that produce strong magnetic fields. Refer to TMS1200 Electrical Installation Technical Specification for segregation requirements.

All control, instrument and communication cables shall have cable tag numbers applied as per TMS1200 Electrical Installation Technical Specification.

5.6.4.1 Control Cables

Refer to TMS1201 Instrumentation Installation Specification

The Contractor shall supply, install and terminate all control cabling as part of the field equipment installation.

Field control cable shall be PVC/PVC 0.6/1 kV grade, multi-stranded copper multicore, V-75 thermal rating of minimum size 0.75mm².

In all cases where multi-core control cables are used the Contractor shall include at least two (2) spare cores (e.g. if 3 cores of a control cable are required a minimum 5 core cable shall be installed).

5.6.4.2 Instrument Cables

Refer to TMS1201 Instrumentation Installation Technical Specification

Instrument cables run to field instruments shall be twisted pair with overall or individual screens and have minimum core size 0.75mm². The screens of all instrumentation cables shall be earthed at only one point unless specified otherwise by the equipment manufacturer's installation recommendation.

Single strand (solid) cable shall not be used.

The cores of the cable shall be numbered and terminated with a suitable crimp.

5.6.4.3 Copper Communication Cables

Refer TMS1151 Preferred Equipment List – Control Systems for copper communications accepted by QUU.

CAT 5 and CAT 6 cables and serial communication copper cables shall not be installed exterior of buildings and switchrooms unless accepted in writing by QUU.

Copper patch leads inside communication panels shall be colour coded depending on communication function with different colour cables required for fire systems(red), safety function control systems(red), general process control(blue), telephone(yellow) and intranet communication signals(yellow), Profinet cables (green). The Contractor shall propose colour coding of patch leads for other signal types for QUU acceptance.

Screened CAT5 and CAT6 cables with industrial connectors shall be installed at STP production areas for all PLC/RTU connections, critical plant and control system infrastructure. A maximum length of 90m must be adhered to.

5.6.4.4 Fibre Optic Communication Cables

Refer TMS1151 Preferred Equipment List – Control Systems for fibre optic cable types accepted by QUU.

Fibre cables shall be installed to equipment where communications to field devices (external of buildings) is required, unless specified otherwise in the Project Documentation.

Fibre cables shall be multi-mode unless otherwise stated in the Project Documentation. Fibre cables shall be supplied with 25% spare unused cores. Minimum bend radiuses shall be adhered to based on the manufacturer's specifications.

The Contractor must submit calculations for the fibre installation taking into account the intended transmission speed, total route length, core thickness, insertion losses due to joins and connectors, cable quality, the fibre transceivers maximum transmission distances. The Contractor shall also submit final results of OTDR testing to QUU for acceptance.

A minimum of a twelve core fibre cable shall be installed unless specified otherwise in the Project Documentation. Twelve core fibre cables can be replaced with two parallel six-core cables if required. Fibre cables shall be rodent and insect resistant. Steel wired armoured cable shall be provided where there is possible mechanical damage to the cable at any point on the installed route.

Fibre service loops shall be maintained in cable pits, communications cabinets and cable racks. Cable pit lids must fit securely with service loops neatly secured in place.

Fibre rings shall be installed at STP sites and other sites 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 supported by a risk assessment that identifies the proposed approach does not introduce unaceptible risk.

5.6.4.5 Fibre Cable Termination

Fibre cable cores including all unused cores in the cable shall be terminated at a FOBOT at both ends of the cable. Refer to TMS1151 Preferred Equipment List – Control Systems for FOBOT's accepted by QUU.

Fibre connectors shall be LC type for new installations. The Contractor shall ensure the connectors conform to any existing site installation or the best fit to the control system devices. The Contractor shall also ensure the selected connectors are suitable for the process conditions such as high humidity, dust, moisture and vibrations.

The Contractor shall ensure the suitability of the connectors and provide the same the type of connectors currently installed when connecting a cable to an existing FOBOT. The Contractor shall ensure that patch leads will not bend excessively when closing the access doors of FOBOT's and communication panel doors and fitting side or rear panels of enclosures.

The FOBOTS shall be minimum 24 way and allow for a future 12 core cable to be terminated. All FOBOTs shall be rodent proof with all holes securely sealed.

Rack mounted FOBOTs shall be installed within RU communications panels. Compact FOBOT's (DIN Rail of gear tray mounted) shall not be accepted in RU communications panels.

All fusion splice joins shall be housed within splice cartridges within the FOBOT. All fibre cores shall be terminated in the FOBOTs. All unused fibre ports shall be capped at the FOBOT to prevent the ingress of dust.

The fibre cable shall be supported and restrained by appropriate cable duct or brackets inside communication panels. The weight of the cable shall not be supported by the FOBOT enclosure.

FOBOT's shall be installed in readily accessible locations. Installation of FOBOTs inside lighting poles or other restricted access areas is not accepted.

The Contractor shall assign unique tagnames to FOBOT's that match the fibre cable termination diagrams. The physical locations and identification by tag number of all FOBOT's shall be shown on equipment and site layout drawings.

5.6.4.6 Fibre Patch Leads

Refer TMS1151 Preferred Equipment List – Control Systems for the patch leads accepted by QUU.

Fibre patch leads shall be multi-mode type supplied with LC connectors and of adequate length to suit the installation. Excessive length of patch leads is not accepted. The patch leads shall be neatly secured using a cable management system and not prone to mechanical damage or stress when accessing the panels. The Contractor shall insure the connection is suitable to the process conditions such as excessive humidity and vibration.

Fibre patch leads shall be colour coded depending on communication function with different colour cables required for fire systems (red), safety function control systems (red), general

process control (blue), telephone (yellow) and intranet communication signals (yellow). The Contractor shall propose colour coding of patch leads for other signal types for QUU acceptance.

Rugged OM3/OM4 patch leads that meet the above specification shall be installed where fibre patch leads are required to transition outside of an electrical enclosure.

5.7 LABELS AND EQUIPMENT IDENTIFICATION

Refer TMS1222 Control Panel Technical Specification for equipment labels required in control and communication panels.

A label shall identify each component or hardware device in the control system. The label material, size, wording and layout of the label, must be in accordance with the design drawings, equipment list and instrument index and shall be supplied and installed in accordance with QUU's specifications.

Labels shall be supplied by the Contractor for all control system equipment not defined in the Project Documentation. Unless specified otherwise, labels shall comply with Project Documentation.

All labels including control and marshalling panel labels shall be UV stabilised exterior grade acrylic, with black lettering on a white background and fixed with SS316 screws to the exterior of the panel. Equipment labels inside panels shall be fixed with industrial grade adhesive.

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.

All labels and nameplates for indoor use shall be manufactured from Traffolyte material, with black lettering on white background, unless specifically stated otherwise.

Labels shall be glued and fixed with at least two 304 Grade stainless steel screws per 120 mm label length. Self-adhesive labels are not accepted. Screw holes shall be slightly enlarged when necessary to prevent buckling of the label.

NOTE: Inside enclosures the labels are to be fixed as close as possible to the identified item, yet not on the cable duct cover. i.e. on the gear tray behind and above item of equipment to be identified. Fixing the label onto the duct cover is not acceptable. Labels shall not be fixed directly onto control systems equipment in the event that the part is replaced in future.

For outside use, labels shall be engraved high quality stainless steel utilizing permanent deep surface marking, black in colour. Fixing shall be with stainless steel screws or stainless steel cable ties.

Labels shall be fixed adjacent to (preferably above, but not directly on) the particular item of equipment they identify, with the wording horizontal.

Wording on labels shall be in capital block letters.

6 RTU, PLC AND SCADA SOFTWARE CONFIGURATION

The Contractor shall follow the configuration guidelines for Programmable Control Equipment presented in this section for all QUU sites. Where existing QUU standard software code and configuration is not available the Contractor shall configure the RTU, PLC, HMI and SCADA control systems to meet the following minimum requirements:-

- Adhere to existing QUU 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;
- All 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;
- QUU preference is for standardisation of all hardware, software and system configuration parameters of SCADA. QUU standard code shall be used where available and QUU preferred equipment lists applied where applicable.

6.1 PROGRAMMING SOFTWARE LICENCES

The Contractor shall supply all proprietary RTU, PLC, HMI, Communications and SCADA programming software unless otherwise specified in the Project Documentation. The software shall be licensed to QUU for each and every project. The Contractor shall supply all programming software for all programmable devices. The contractor shall supply terminals, dongles, interface cables and all miscellaneous items to correctly configure the control system.

The software licences may be utilised by the Contractor for the duration of the project, however the software, licences and all associated hardware, cabling and documentation to configure the control system components shall be delivered to QUU at Practical Completion.

At STP sites the EWS shall have all software installed and all engineering software programs ready for use, prior to commencing commissioning of any plant production areas or processes. This includes and is not limited to the software licences for configuration, fault finding of PLCs, RTUs, SCADA, Local HMIs, protocol gateways as well as centralised asset management software such as PDM, Fieldcare, and Simocode ES Premium.
QUU defines the commissioning phase commencing when the control system and other equipment are first introduced into normal service to control and monitor the process or production area.

6.2 RTU, PLC AND SCADA PROGRAMMING

The Contractor shall be responsible for the configuration and programming of RTU, PLC, communication device and SCADA systems as specified in the Project Documentation. All configuration and programming shall follow the project specific and QUU accepted Functional Specification, Control System Software Requirements and HMI User Manual documents.

All PLC and SCADA programming methods and conventions adopted by the Contractor shall comply with the QUU programming standards and guidelines:

- i.e. for Citect SCADA systems refer to TMS849 Citect SCADA Configuration Standards and
- TMS1229 PLC Programming Configuration Standard

All RTU and PLC programs shall be designed and written to conform to IEC 61131 using the PLC manufacturer's standard programming software and techniques as recommended by the original equipment manufacturer.

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

The Contractor shall use the QUU standard I/O Naming Convention to identify I/O points within the RTU/PLC. All I/O shall be addressed within the software by reference to these names, and exclude actual dedicated I/O naming or addressing. This naming convention shall be utilised by SCADA also, to ensure a consistent naming convention from signal origin through all data acquisition equipment such as RTU, PLC, SCADA and telemetry (where applicable) thus ensuring that the same signal will have the same name in all systems.

On request from QUU, the Contractor shall submit all code developed at any stage of the project and facilitate QUU's review of progress and compliance to the standards and specifications.

The Contractor must ensure they have access to all necessary programming software to fully develop, test, evaluate, revise and commission the software.

The Contractor shall demonstrate experience with the implementation of the software licences specified in the Project Documentation. Approved software licences for use on QUU facilities are listed in TMS1151 Control Systems – Preferred Equipment List.

The Contractor shall determine existing PLC and SCADA site specific software versions and licences as well as confirm the compatibility of control system hardware at each site prior to Contract award. The QUU Software Management System is under development and the Contractor shall make enquiries with QUU to determine the latest requirements before commencing new software development or modifications to existing software.

The Contractor shall only make changes to existing control systems after the Contractor has been authorised by QUU and the proposed change has been accepted by QUU. The Contractor shall be responsible for completion of the FOR603 Control System Change Management Form and in accordance with PRO396 Change Management Procedure. The Contractor shall be responsible for completion of all QUU Permit To Work forms and approvals prior to commencement of any onsite work.

6.3 ADMINISTRATION PROCEDURES

6.3.1 File Back-up and Security

The Contractor shall transport backups of configuration and system files in a secure manner by use of encryption and QUU approved storage devices. Backups shall not to be shared without the written approval of QUU. All backups are to be treated as confidential and as the property of QUU.

The Contractor shall submit the factory tested software code to QUU via the Sharefile website or other agreed method. QUU will screen the files prior to moving the files onto the QUU storage environment. The Contractor shall not plug any USB's or portable hard drives into QUU devices.

The Contractor shall not connect non-QUU laptops into any control system devices this includes SCADA network switches, SCADA communications ports or RTU/PLC. During SAT the Contractor shall work from the QUU supplied laptop or STP local engineering station. The Contractor must be approved by QUU to access any existing control systems equipment or undertake any actions on control systems that may impact existing plant production or processes.

The Contractor shall ensure that all new devices are hardened to only allow processes that are required for the proper operation of the SCADA system. The Contractor shall disable all services not required by SCADA i.e. emails, internet browsers, FTP software, network ports, USB ports, unused transmission protocols, wireless etc.

For STPs, an up-to-date backup of all software configuration files must exist on the EWS at the time the plant process or production areas goes into service or anytime live sewerage is introduced into the system.

For network sites, the up to date software configuration files must be immediately available to QUU during and at the completion of the work.

6.3.2 Back-up Procedures

The Contractor shall implement a written administrative and procedural system for backing up the configuration files and control system files shall be defined and shall include any procedural variation required as the project moves through its various phases.

Comprehensive written procedures shall describe the necessary steps required to back up and restore the configuration files for the project.

The File Backup/Security system shall address issues relating to security of the back-up copies, such as storage location, number of copies, backup frequency and the life of the back-up media.

Copies of the backed up configuration and system files shall also be preserved at various milestones as defined in the Project Documentation.

6.3.3 Logbooks

The Contractor shall maintain a log book or similar system that captures the status of all backup copies of the configuration and software files.

6.3.4 Documentation

The Contractor's internal software management procedure shall be revised as required to include considerations specific to the project and process. Where applicable the QUU back-up procedures shall be closely followed for any on line software applications. The Contractor shall make their own enquiries as to what QUU minimum requirements are for on line software back-up and change management.

6.4 CONTROL DOCUMENTATION AND CONFIGURATION

The Contractor shall provide all control system documentation and other deliverables as per the Contract scope of work and/or nominated in the SDRL included in the Project Documentation.

Refer to Section 8 of this document for a complete suite of control system documentation required to be delivered by the Contractor.

6.5 PROCESS PARAMETER MANAGEMENT

6.5.1 Signal Scaling

Scale high and scale low parameters will generally be set to the equivalent process values as measured by the field measuring device. Preferred scales shall be used, the intention being that full-scale value and the associated values at fractional scale markings are sensible numbers.

Ranges shall be in commonly accepted standard SI (metric) units or derivatives.

Scaling shall not be performed in the SCADA software project. Scaling within the SCADA platform is to maintain a 1:1 ratio. All scaling is to be conducted within the RTU/PLC.

6.5.2 Variable Addresses

Variables shall be allocated to a physical hardware address only where this is required for the control system selected. In general, hardware addresses may be required for:

- Physical input and output addresses
- Communication buffers
- Bulk alarm handling

6.5.3 Variable Scope

The standard allows the declaration of variables that have either global scope (accessible to the whole program) or local scope (accessible only to one program file). The following rules shall be used:

- Inputs and outputs shall have global scope and variable names based on the equipment tag (see below).
- Communication buffer files should have global scope (unless all buffer packing and unpacking is handled inside one program file) and depending on the system selected, may need to be assigned a hardware address to permit remote communications.
- Depending on the system selected and its alarm processing mechanism, alarm matrix buffer files may require global scope so that all alarms can be consolidated into one array for matrix processing.
- Internal variables (both Boolean and numeric) that are used for passing data between different program files, or which provide data of potential use to many program files (such as a computed value corresponding to a real process condition) should have global scope.
- Everything else should have local scope. This includes all temporary variables, intermediate calculation results, flags, latches, timers, counters, one-shots, and PID blocks. There should be no need to assign hardware addresses to any of these.
- A ready method of distinguishing between local and global variables shall be established. This may be an inherent feature of the system selected or may need to be defined.

6.5.4 Variable Names

All variable names used within the PLC code shall comply with TMS1229 PLC Programming and Configuration Specification. This will apply to all devices that are interfaced with the PLC such as instrumentation, drives and valves. Wherever possible, these conventions shall comply with equipment tags as defined in the QUU Ellipse asset register TEM114.

All variable names used within SCADA shall comply with TMS849 Citect SCADA Configuration Standard. All variable names used within STP local HMI terminals shall comply with TMS849.

All variable names used within Networks local HMI terminals shall comply with the associated RTU/PLC tag naming convention.

6.5.4.1 Inputs and Outputs

The tag number shall be identical to that assigned to the wiring connected to the input or output. Signal tags for wiring, I/O and other signals shall incorporate the instrument or equipment tags as defined in the asset register, plus a suffix describing the purpose of the I/O. The suffix may be as long as the programming software allows up to a limit of five characters. The suffix must be standard across the project. A list of standard suffixes is included in TMS1229 PLC Programming and Configuration Specification. Wherever possible, the Contractor must use suffixes from specification.

The variable name shall reflect the “active” or “On” state of the signal.
Eg. tagname “PU001dsFault” indicates that the pump is faulted when the status is ON

The PLC project is to contain only one instance for every analogue, digital, input or output variable in use. Multiple instances of the same signal are not permitted. Reusing a hardwired signal shall not require replacement in several areas of code.

The standard library objects where available shall be used to manage I/O signals. The Contractor shall develop the standard library where it is not provided. All digital I/O shall be processed prior to its use in the program. Digitals signals shall be debounced and inverted if required.

All Analogue inputs shall be processed through an analogue input function block. As a minimum the function block shall perform the following:-

- Verify the raw signal is valid and within bounds,
- Scales the value from raw to engineering units,
- Filters the value over an adjustable period
- Clamps output to high or low boundary limits
- Incorporates high high, high , low and low low alarms
- Provides alarm masking when put Out of Service
- Includes totaliser functionality

After the initial processing, the analogue scaled value may then be used as required.

6.5.5 Naming Conventions

Naming conventions shall be established for descriptors, file names, folders and equipment as applicable to the system being configured. Wherever possible, these conventions shall comply with equipment tags as defined in the QUU Ellipse asset register TEM114.

6.5.6 Variable Descriptors

Comments (descriptors) shall be entered for all variables including all I/O and internal variables. Descriptors for hardware modules shall include reference to physical location (room/cabinet/rack/slot).

Variable descriptors shall be shown wherever a variable is referenced in a control program. Descriptors of variables that are part of a structure shall include the description of the structure, not just the variable itself. For example, the description of the variable PU1234567.acAuto should be “RAS Pump 1 : Auto Mode”, not just “Auto Mode”.

If the control system does not provide this facility automatically, or the automatic facility provides inappropriately placed or inappropriately sized descriptor text, then text descriptors shall be provided as comments adjacent to where the variables are referenced.

6.5.7 Commenting

All programming and configuration shall be commented liberally and appropriately to make clear the intent of the logic.

Identifiable sections of logic shall be commented with details of the function of the section. Program modules shall have a header comment describing the operation of the module. For example, drive logic shall include a title that includes the plant area, drive description and drive number. Other program modules may require more extensive commenting. Sections of logic may require commenting such as ‘Remote-Local logic’ or similar. 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 and descriptor (and engineering units if applicable) of a function block, then this method of commenting shall be used preferentially to provide this information. This does not mean that any additional commenting is not required.

If program modules do not inherently list the global variables used or set by the module these shall be listed as a comment. Real inputs and outputs of the program module shall be commented on the function block diagrams or program modules if this is not inherently displayed on the diagram or module. This means that it shall not be necessary to ‘drill down’ to obtain this detail.

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

All 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.

The interconnection and interaction of analogue 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. The object is to improve the readability of the logic.

Calculations shall be commented to ensure ease of understanding. Particular care should be taken to identify constants used. For example, a constant 101.32 may be labelled Reference_Pressure_kPa. If a constant is the result of a combination of factors, then 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.

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

6.6 COMMUNICATIONS

For PLC and HMI communications refer to TMS1229 PLC Programming and Configuration Specification.

For SCADA communications refer to TMS849 Citect SCADA Configuration Standards.

6.6.1 ICS Protocols

6.6.1.1 Preferred Protocols

Only International Standard Protocols are accepted. Devices shall utilise a common ISO/IEC listed open communication protocol. All 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 with the following protocols accepted:-

- Ethernet/IP
- Modbus TCP
- DNP3
- ProfiNet
- IEC 61850
- OPC

Ethernet is preferred and RS485 can be accepted for communications between devices located in the same enclosure and both owned/operated by QUU. RS232 serial communications is the preferred method for connecting to thin bandwidth communications devices such as radio modems. Other physical layer connection standards are not accepted unless specified in the Project Documentation or accepted in writing by QUU.

6.6.1.2 HV Protection Relay Communications

The IEC 61850 communication protocol shall be provided where communications between IED's is required for HV equipment protection schemes. Profinet and Modbus /TCP protocols are accepted for communications between IED's where HV equipment protection functions are not required.

Where IEC 61850 protocols are required the entire protection communication network between IED's shall be implemented with IEC 61850.

6.6.1.3 Protocol Converters

Where third-party protocol converters are used, all data-mapping and settings shall be documented in the Control System Administration Manual. The converter must be powered from the PLC's fixed supply and not to be powered from a separate power outlet.

Where a GE RX3i and a Siemens PLC share inter-PLC data (such as a SPRI switchboard in an STP), 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 QUU SCADA master clock time.

6.6.2 LAN Configuration

Refer to section 5.6.4.4 Fibre Optic Communications details.

6.6.2.1 Fibre Ring Topology

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. All PLC's 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.

6.6.2.2 Network Monitoring and Security

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

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

6.6.2.3 Network Capacity

The Contractor shall provide for a maximum site communications network utilisation of 20%. The Contractor shall provide an estimated network utilisation calculation in the network design. 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.

6.6.2.4 Field Instruments and Devices

All instruments, devices and drives shall be configured and managed from the EWS where practical.

Field instruments and the devices shall not communicate directly with the SCADA servers. All field devices shall connect to the PLC via a communications link, the instrumentation bus or else by hardwired signals.

The Contractor shall provide and install all the licenses and gateways for fieldbus instrumentation projects. 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. All required software licences and configuration files shall be installed onto the EWS for site backup purposes.

The Contractor shall provide and install licenses, software and cables for centralised management of all drives and motor protection relays as required for the project. 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.

6.6.2.5 Usage of Wi-Fi

Refer to TMS1151 Preferred Equipment List – Control Systems for Wi-Fi Access points that are accepted by QUU.

Wi-Fi is restricted and shall only be used for moving or rotating platforms thus removing the need for slip-ring, catenary wiring or tuned-pair radio links or RTU.

The QUU ICT Security department will review all Wi-Fi connections proposed.

The following rules shall be adhered to by the Contractor for all proposed Wi-Fi installations. All departures shall be accepted in writing by QUU ICT Security.

Wireless Access Points – Configuration Rules
AP mode only is accepted. Bridge mode is not generally accepted by QUU. If no other alternative and is required to use Bridge mode, QUU will consider specific scenarios (e.g. replacing point to point radio links)
Disable WDS
Document of SSIDs must be provided by the Contractor. Contractor shall nominate the SSID and is based on the project naming conventions. The SSID shall not include 'QUU' or the functional name of the plant/equipment/location in the SSID.
Disable SSID broadcast
Operation mode shall be G rather than B/G as a fall back.
Must use WPA2-Personal using AES or WPA2-Enterprise. WPA2-Enterprise shall be provided where is available. Pre-Shared keys must be random, using at least 32 character spaces. Key renewal can be the default 3600.
DHCP is not available on the SCADA network and shall not be used.
MAC Filtering shall be used for specific known devices.
IP port filtering shall be used for only a specific protocol.
If SNMP is configured (recommended for monitoring purposes), only SNMPv3 shall be used, with password configuration and minimum, password + key required. SHA and AES shall be used. MD5 should not be used.
Syslog logging shall be configured.
HTTP/HTTPS and Telnet connections shall be disabled and where not possible the SSH is the only protocol that shall be used. HTTPS can be enabled for a short period of time to do certain tasks, e.g. firmware upgrade and shall not be used for other possible functions.

Wireless Access Points – Configuration Rules
Any system password must follow standard policy guidelines (8+ characters, at least 1 capital, at least 1 number, at least 1 alpha). All Passwords shall be provided to QUU in writing.

6.6.2.6 Network Architecture Drawings

The Contractor shall provide new or amend existing Network Architecture drawings to cover the complete design within the scope of work of the project.

The Contractor shall revise existing drawings using AutoCAD 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 QUU. The Contractor shall submit the design drawings approved by an RPEQ electrical or control systems engineer.

The Contractor shall prepare new and/or update existing drawing 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;

- Network Panel Diagrams: Control Panel or Communication panel drawings showing the FOBOT and network switch port numbers and all communication cable connections. The hardware and critical settings shall be included on the drawings. All fibre core numbers and cable numbers shall be included.

- Site Network Topology: drawings displaying all fibre cables, network switches, computers, firewalls, proxies and gateways, fibre spurs, PLC connections, Wi-Fi connections, WAN connection, HMIs.

- Site layout drawing. This drawing shows the cable route for all fibre optic rings, fibre spurs, fieldbus communications cables, position of all Wi-Fi access points, RTU etc.

Note: IP address information shall not be shown on drawings. The IP addresses for all equipment supplied, installed or modified by the Contractor shall be provided in an excel file to QUU.

6.7 POWER FAILURE LOGIC

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

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

After power is restored the RTU/PLC shall initialise with realistic (i.e. non zero) default settings hard coded in the program or read from SCADA. 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 are maintained following the power restoration.

All new and modified 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.

6.8 PLC HARDWARE

6.8.1 Hardware Log

The PLC processor on-board status logs shall be displayed at the SCADA. All history, status and diagnostic data available in the PLC shall be displayed. The SCADA shall store the data in the event that communications with the PLC fails.

6.8.2 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

As a minimum the Contractor shall provide evidence of the following:-

- Zero errors within the diagnostics buffer RTU/PLC during FAT and SAT
- Minimum of 40% spare processing capacity
- Minimum of 40% spare memory capacity (inclusive of all on-board RAM & ROM, removable memory cards)
- Minimum of 20% spare installed I/O of each card type
- The CPU shall be configured with error handling routines for all hardware interrupts such that the CPU will continue to run.
- 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.

Sufficient PLC processor memory space shall be designated and configured to allow for future software expansion including additional working memory, and non-volatile variables, timers and counters.

All retentive memory shall be retain after a hot-restart, warm-restart and a cold-restart.

6.8.3 I/O Module Arrangement

The Contractor shall assign the I/O modules in the RTU/PLC in accordance with the following guidelines:-

- All devices within the same duty group are distributed across multiple I/O modules. Failure of a single I/O module shall not result in total loss of operation
  Eg. Pump1 and Pump2 should not be wired into the same I/O card such that failure of one I/O card will fault both pumps.
- All analogue inputs used in a cascade PID loop shall be distributed across two separate analogue cards if a second card is installed. Failure of the second analogue 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. The Contractor shall minimise and rationalise inter-PLC signals for critical control functions.

6.9 OPERATOR STATIONS

Operator stations in this specification refer to both SCADA client workstations and local HMI terminals. It is noted that some features specified may not be available in some standard local HMI terminals and the Contractor shall seek QUU's acceptance of the limited product features during the detail design.

6.9.1 Operating Philosophy

Refer to TMS849 Citect SCADA Configuration Standard for sewerage treatment plants. Refer to QUU Standard Functional Specifications for the particular Network Asset type that defines the SCADA operating philosophy.

6.9.2 Security Levels

Refer to TMS849 Citect SCADA Configuration Standard

The Contractor shall implement standard QUU security levels for user access to the SCADA where applicable. The security levels shall be defined to limit the scope of access that is available to the user logged onto the system. The Contractor shall refer to the site specific SCADA Client Workstation and HMI User Manuals where available or refer to the existing configuration of the site SCADA to determine the conventions to be adopted when implementing SCADA security levels.

The following shall apply unless specified otherwise by QUU or the Project Documentation:-

Security level types that shall be defined include 'Monitoring Only', 'Operator', 'Supervisor', 'Engineer' and 'Administrator' unless specified otherwise by QUU.
All functions will be "grey out" to users with insufficient privileges.

6.9.2.1 User Authentication

Each user must be assigned an individual logon by the systems administrator. Individual user logon shall enable that user to the level of access granted by the security levels assigned to that user. Logon security shall be provided by Active Directory Authentication where available. Should the system not provide for Active Directory, the user identity verification system is the minimum acceptable verification for password-based system.

6.9.2.2 Record of User Logins

The SCADA must be configured to monitor the actions of the user currently logged on at each node. The SCADA shall event log all user logins and provide traceability of all user actions.

6.9.2.3 Automatic Logout

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' 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.

6.9.2.4 Monitoring Only Access

When the system is started the workstation shall default to a 'Monitoring Only' access level and shall not require login. All other access levels require login.

'Monitoring Only' access level shall not allow any interaction with the control system variables or parameters other than monitoring. Access to the Windows start menu and hot keys such as Ctrl Esc, Ctrl Alt Del shall be locked out

6.9.2.5 Operator Access

'Operator' access level shall allow access to all 'Monitoring Only' functions plus the control mode, set point, manual output, ratio settings of regulatory control loops unless otherwise specified. Access to stopping/starting of drives, opening/closing of valves, control of sequences, selectors is also permitted by 'Operator' access level. Initiation of preconfigured reports is also permitted at this level. Operators shall have the capability to issue a manual poll command to network device(s) in order to refresh the HMI screen. Access to the Windows start menu and hot keys such as Ctrl Esc, Ctrl Alt Del shall be locked out

The default access security level for regulatory control and monitoring faceplates shall be set to 'Operator' access unless specified otherwise.

The default access security level for motor stop/start control faceplates shall be set to 'Operator' access unless specified otherwise.

6.9.2.6 Supervisor Access

'Supervisor' access level shall allow access to all 'Operator' functions plus alarm settings and other plant operational parameters that may need to be changed by a supervisor.

Resetting of plant throughput counters is also permitted at this level. Access to the Windows start menu and hot keys such as Ctrl Esc, Ctrl Alt Del shall be locked out

6.9.2.7 Engineer Access

'Engineer' access level shall allow access to all 'Supervisor' functions plus all alarm, trip and parameter settings, configuration/download and programming access but shall not permit access to any system administrator functions such as password administration.

6.9.2.8 Administrator Access

'Administrator' access level shall allow unrestricted access to the control system including all the functions enabled by other access levels. Creating and modifying accounts is also permitted at this level.

6.9.3 Graphics – General Principles

Graphics shall show all necessary detail. Detail not generally required while operating shall be accessed at a lower level of graphic windows accessed from touch/cursor points. Process line colour shall conform to project colour standards. It is preferred where practical that symbols from ISA for Piping and Instrument Diagrams are used to depict process elements.

Citect SCADA equipment colours shall be animated to conform to QUU project colour standards. These colours are detailed in TMS849 Citect SCADA configuration Standard. Refer to the existing QUU site standards for ClearSCADA, Mosaic, Radtel and SCADA-C.

Process line thickness shall be defined based on a philosophy that the main process lines shall be thicker than minor or ancillary process lines.

To avoid cluttering graphics with information that is only needed occasionally, techniques to hide or display detail unless required shall be employed. For example, options to hide or display descriptors, tag names, minor process lines or data lines can be provided to the operator. A standard approach shall be described.

To assist in reducing the 'cluttered look' of complex graphics, it may be beneficial to group related data into tables rather than display them individually.

Where possible, the location and orientation of equipment and piping shall be displayed in an orderly fashion. All process lines shall be displayed either vertically or horizontally.

Minor equipment that are being displayed graphically (e.g. valves) should be aligned both vertically and horizontally, where possible.

The screens shall each display the last successful poll in the top right hand corner and the communications channel in use i.e. radio modem or other communications link used to receive the information.

6.9.4 Hierarchy of Graphic Displays

6.9.4.1 Overviews

A single Custom Overview graphics of the whole plant shall be provided. This shall provide access to Custom Overview graphics of individual plant areas.

6.9.4.2 Major Plant Areas

Custom Overview graphics of individual Plant Areas shall be provided. These shall provide critical control parameter monitoring information for each plant area. In general these will not provide operator with control access, but will enable the operator to access Custom Operating Graphics. This must be in general compliance with the existing plant specific SCADA graphics display hierarchy.

Trend Overviews shall permit the operator to easily navigate to a particular trend display.

6.9.4.3 Operating Graphics

Custom Operating Graphics shall be provided as the basic operating graphics used by the operator to monitor and control the plant.

The objective is to provide the operator with clear yet comprehensive monitoring and control of the process, using a process view (similar to a P&I diagram) that mimics the plant.

The number of Custom Operating Graphics developed per plant operating area shall be determined by the complexity of the plant being depicted.

6.9.4.4 Detail Graphics

When the operator needs more detail than provided by the normal operating graphic, a more detailed level of graphic shall be provided. For example 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.

6.9.4.5 Diagnostic/Status Pop-up Windows

Diagnostic/status pop-up windows shall be provided for all drives, valves and systems where interlocking can trip or interlock out that equipment.

6.9.5 Trends

Unless otherwise specified, trend pens shall be assigned for all analogue process variables.

The Contractor shall implement QUU standard trend template screens where applicable.

Where not provided by QUU the standard screen template for trends shall be developed by the Contractor and shall include the following:-

6.9.5.1 Trend Display

The trend display shall be as per site standardand must be archived after a three month period.

6.9.5.2 Trend Redundancy

Trend collection and management must be configured to utilise both Primary and Standby Trend servers. Both servers must contain all trend information. If the Primary Trend Server fails then the Standby Trends server must ensure all trend functions continue to operate. Upon restoration of the Primary, the Standby must automatically update the primary server such that there are no gaps in the historical trend data. No operator involvement must be required. Failure of the servers must be monitored such that a failure of either server will produce a diagnostic alarm.

Communications failure between the two servers shall force both servers to become active and both interrogate all I/O Devices. On resumption of the communications failure, both servers shall automatically consolidate their trend information. This situation may occur with a broken ring network on an STP with both servers located in two different geographical locations.

The above mentioned functionality will be dependent on the capability of the existing QUU SCADA system for the site.

6.9.6 Navigation

The configuration for a standard method of navigation provided for the plant operator shall be described. An important objective to be achieved is consistency in methods of interfacing the operator with a hierarchical structure of display screens.

6.10 ALARMS

The SCADA system will be developed with adherence to “ANSI/ISA-18.2-2009 Management of Alarm Systems for the Process Industries”. 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 Contractor shall provide their methodology to achieve adherence to these requirements.

6.10.1 Signal Monitoring

Whenever possible, signal monitoring functions for alarming and or tripping shall be implemented by the built-in signal monitoring capabilities of loop instruments.

'High' and or 'low' alarm points shall be configured. Additionally, smart alarming practices shall be used where required.

All ethernet switches, UPSs, PLCs, RTUs, SCADA server and power supplies shall be alarmed during a failure or loss of communications.

6.10.1.1 Networked RTU's

Networked RTUs shall use the DNP3 protocol in order to retrieve time stamped data, alarms and events. Existing telemetry systems consist of a variety of protocols such as DNP3, and KF2.

Report by Exception Alarms raised by the RTU shall immediately send the new alarm and instigate a request to the Master RTU for a full poll. The alarm is then received in the QUU Network Control Room. The Master RTU will then upload all time stamped DNP3 data inclusive of statuses and events. If the RTU does not raise an alarm, all statuses and event will be uploaded during the next cyclic poll.

6.10.1.2 STP PLC's

All alarms in Brisbane and Ipswich and some regional STPs annunciate alarms to the local SCADA Citect servers. The alarms are displayed on alarm pages and high priority alarms paged to operators if configured.

STPs which do not currently use Citect, use "general alarms" and hardwired signals into the Radtel or SCADA-C (Elpro) master RTU.

6.10.2 Alarm Categories

All projects shall use the alarm categories as defined in the existing SCADA system for that site. An alarm list indicating the alarm categories shall be provided by the Contractor for QUU for review. The assignment of each category shall be based on the alarms criticality in the process. The alarm categories must be accepted by QUU. The alarms and their agreed categories shall be recorded in the site Functional Specification. Under no circumstance shall alarms be categorised as an event such that it will not appear on the alarm page when triggered.

The category colours for alarms in STPs shall be as listed in TMS849 CITECT Configuration Standard. Note that the category colours in the Citect specification may vary from those used in Mosaic, ClearSCADA, Radtel and SCADA-C

The system must be capable of assigning a specific audible tone for each category of alarm.

6.10.3 Alarm Minimisation

The management of alarms is critical to plant reliable operation. An important requirement is the minimisation of alarms that are merely consequences of other alarmed conditions.

Alarms shall be minimised by:

- Masking of process alarms caused by drives not running.
- Masking of high motor current alarms during motor run up times.
- Filtering of transient alarms on process variables (both analogue and discrete). Use of time delay or hysteresis functions included in standard function blocks may be applicable here.
- First alarm trapping and disabling of alarms consequent to the first alarm.
- Masking of plant area alarms depending on the status of the plant area.
- Existing conventions adopted in the SCADA configuration to minimise alarms at the site shall also be adopted for any new modification works to ensure site wide consistency.
- Masking of consequential alarms caused by utility power supply or other normal power supply unavailable at the site.
- Removing all associated SCADA alarms for all removed equipment. Disabling the alarm in the SCADA is not accepted and the alarm must be completely removed.
- Masking of alarms for all equipment that has been put 'Out of Service' by the operator. A low priority alarm shall be displayed for each device put out of service.

6.10.4 Further Details Alarms and Events

The SCADA configuration shall be integrated such that an alarm acknowledged on one SCADA node can receive acknowledgment on the other nodes. The alarms must be configured as one common database, with no other programming necessary to enable global acknowledgment of alarms from any HMI on the network.

6.10.5 Alarm Detection

The SCADA configuration shall monitor analogue and discrete variables and calculated conditions, and determine if the variable is in an alarm condition.

For each Analogue Tag, an alarm for each of the following conditions must be configurable:

- Variable LOW-LOW, Variable LOW, Variable HI, Variable HI-HI
- Deviation LO, Deviation HI
- Rate of Change HI

The Contractor shall update the Analogue Function Block library as required to comply with these requirements.

Analogue alarms must have an adjustable dead band. All analogue alarm properties must be adjustable without shutting the system down. Changes must automatically be saved to the database so that if the system is restarted then the alarm settings will be retained.

For each Discrete Tag, an alarm for each of the following conditions must be configurable:

- Variable ON, Variable OFF
- Combination of any two Discrete Variables

Discrete alarms must have facility for time stamping, to enable tracking to a precision of maximum 2 seconds. It must be possible to determine the order of occurrence of discrete alarms. The I/O Device scan rate of the SCADA system determines the precision.

6.10.6 Alarm Display

The alarm display must remain consistent with the existing SCADA system for the site and the SCADA HMI's must have a consistent alarm display across each SCADA network.

It must be possible to display the following information for each alarm as it appears on an alarm display page:

- Alarm Tag Name
- Alarm Description
- Value of the Variable
- Trip point
- Alarm Status - Disabled, Acknowledged, Unacknowledged
- Alarm Category
- Alarm Priority
- Time & Date in International Formats
- Operator Comments
- Value of any Tag or result of any calculation.

Alarm colour schemes for STP sites are detailed in TMS849 CitectSCADA Configuration Standard.

At any node on the system it must be possible to acknowledge alarms individually, by category or by page.

Where supported the SCADA configuration shall allow for operator comments to be attached to any alarm when it is acknowledged or at a later time. It must be possible to automatically display any graphic display when an alarm occurs or to dynamically change the appearance of any graphical object based on whether an alarm is On, Off, Acknowledged, Communications Error, Disabled or any other available parameter.

An alarm inhibit function shall be provided for alarms for a defined period of time to disable alarms caused by known operational issues with equipment or equipment being selected out of service for routine preventative or break down maintenance.

The alarm display must have a mechanism for operators to dynamically define filtering of alarms by alarm name, tag name, date /time range, state or type.

6.10.7 Alarm Summaries

Alarm Summary displays shall provide a chronological listing of all alarms. Filtering and sorting functions shall be available.

6.10.8 Alarm Logging

All new alarms shall be configured for alarm logging as per the existing SCADA configuration for the site.

For each alarm category it must be possible to define a different method of logging alarms. It must be possible to define if alarms are to be logged when the alarm transitions to ON, to OFF or on Acknowledgement.

The alarms must be able to be logged to a designated printer, disk file or database with alarm text and time and date labels. Alarms must be printed or filed in a user-configurable format. The SCADA system must allow logging to any printer on the network. The SCADA must be able to redirect printing to another printer while the system is on-line.

Alarms that are logged to disk must be available for viewing while the system is on line or off line without causing any interruption to data collection. The SCADA must not limit the number of alarms logged to disk.

6.10.9 Alarm Redundancy

All alarm calculations and management must be performed in the Primary Alarm Server.

The SCADA configuration must automatically ensure that if the Primary Alarm Server fails, all alarm functions must continue to operate normally. The SCADA must automatically generate a diagnostic alarm to indicate that the Primary or Standby alarm server has failed. Adding, deleting or modifying alarms must not require any changes to the SCADA configuration that handles the redundancy.

It must be possible to archive data and restore it via simple point and click methods.

Communications failure between the two servers shall force both servers to become active and both interrogate all I/O Devices. On resumption after the communications failure is rectified, both servers shall automatically consolidate their alarm information. This situation may occur with a broken communications ring network on an STP with both servers located in two different geographical locations.

6.10.10 Alarm Paging and Remote Annunciation

All STP SCADA servers shall be provided with redundant alarm paging systems. Failure of the primary pager system on the primary server will enact the secondary paging system. It is required to keep the paging software separate to the SCADA software, preferably running as a Microsoft Windows service. Paging in Brisbane is performed using a bespoke Citect paging system and paging in Ipswich and some regional areas is by SCADAphone via 3G dongles. Regional sites use paging from the Radtel system.

QUU Operations personnel will update contact details and phone numbers as required. Escalation of alarms to the next operator is required should the paged alarm not receive acknowledgement within a predefined timeout period.

The SCADA shall be programmed with an "Operator offsite" test button which shall be activated by the operator on a daily basis prior to leaving site.

All paged alarms will require prior approval by QUU operational personnel. All high priority alarms that are required to be paged shall be configured in SCADA as Category 1 alarms.

6.11 GRAPHIC STANDARDS

The standard graphics colour scheme for STP's defined in TMS849 Citect SCADA Configuration Standard shall be used throughout the plant on all graphic displays. The standard colours have been defined for process lines, equipment status and fault colours and alarm colours to achieve a common look and feel plant-wide.

Other graphics standards shall also be defined in the HMI User Manual by the Contractor to suit the selected process control system where not defined in TMS849. The HMI User Manual must be accepted by QUU as part of the detailed SCADA configuration specification, prior to HMI graphics configuration work being finalised. The HMI User Manual shall be updated to As Built status after commissioning is complete.

Typically these standards will include but not be limited to the following items:

6.11.1 Custom Graphics

6.11.1.1 Display of Data

Data shall generally be displayed in SI engineering units, not as a percentage of full scale.

Exceptions to this shall include level indication where 0 to 100% indication shall be used except in special cases requiring the display of an engineering value. Levels may be depicted graphically as a bar. In any case, the level will also be indicated as a numerical value located as required near the vessel.

In the water network facilities the level and pressure signals shall be displayed in mAHD (meters above Height Datum i.e. sea level)

Data shall be displayed in at least 3 digits, plus a decimal point if applicable.

6.11.1.2 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 shall be 'greyed out' when their functions are not currently available.

- Shall be selected to a sensible default on dialog boxes, pop-ups and control faceplates. Examples of sensible defaults are 'Cancel', 'Exit' and 'Ok'.

6.11.1.3 Display of Drives

Drives shall be displayed on the process graphics as an icon or symbolic representation (drive symbol).

The method for displaying the status of the drive shall be described. Typically this is by dynamic colour modification of the drive symbol. Refer standard colours in TMS849 Citect SCADA Configuration Specification. The method for displaying Maintenance/Manual/Auto Mode and Tripped/Interlocked states of the drive shall be achieved by dynamic text display. The text colour may be modified to reflect normal or alarm indication as appropriate.

The method of displaying the running status of a reversing type drive shall be similar to single direction drives but with the addition of direction arrows. The colour of each direction arrow shall be dynamically set depending on the direction/running status (see Standard Colours)

An individual Diagnostic/Status Graphic shall be associated with each drive.

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

6.11.1.4 Diagnostic Status Graphics

Diagnostic/Status Graphics are generally pop-up window graphics that provide diagnostic/status information for a drive, valve or system.

Generally this is mainly in a tabular format that comprehensively gathers together the status of interlocks alarms and states.

The sense of the text describes the alarm/interlock state.

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.

6.11.1.5 Display of Valves

The status of the valves shall be displayed on the process graphic as an icon or symbolic representation.

The mode of the valve shall be indicated adjacent to the associated valve icon on the process graphic.
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.

6.11.1.6 Sequence Status Displays

Sequence Status Displays are single, comprehensive operator graphic displays, each tailored to provide operational/diagnostic information dedicated to an individual sequence. Sequence Status Displays shall not require the operator to read/decipher any logic or coding that is part of the configuration of the system.

Each Sequence Status Display shall display the status of a sequence to enable the operator to quickly determine the overall status of a sequence. States that shall be displayed as appropriate are 'Inactive', 'Starting', 'Stopping', 'Tripped', 'Ready/Not Ready'.

Each Sequence Status Display shall display the progress of a sequence in a manner that is meaningful to the operator. The operator shall be able to determine the full sequence of actions that the sequence performs from the relevant Sequence Status Display. The current action that the sequence is performing shall be highlighted.

If a sequence involves time delays, the relevant Sequence Status Display shall show the progress of the time delay (by a numeric display of the remaining time). If the time delays are short, this requirement may be waived.

6.11.1.7 Display of Duty/Standby Systems

The duty/standby selection of any drive that is part of a duty-standby arrangement shall be depicted on operating and detail graphics where that drive 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 drive
- 'Duty'/'Standby'/'Out of Service' status of each drive
- 'Tripped' status of each drive (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, then automatic resetting of any latched software drive trip will be required).

6.11.2 Operator Displays

6.11.2.1 General Requirements

The existing HMI screen display conventions installed at the site shall be maintained to ensure a consistent configuration for any new or modification works undertaken by the Contractor at the site.

For new sites or where standard conventions for configuring operator displays have not been widely adopted at the site, the Contractor shall ensure the following criteria is met for works undertaken.

The SCADA configuration must not limit the number of graphic displays possible.

The points (in the current screen) scanned in the system must be guaranteed to be scanned and updated in the system within 2 seconds. Relaxation of this condition is only accepted where the communication channel bandwidth available requires a longer screen update time. The screen update time shall be proposed by Contractor and supported by calculations that nominate all assumptions. The screen update times shall be accepted by QUU before the Contractor commences design or configuration works. The screen update time is a key performance criteria that the Contractor shall meet. Colour alone shall not be relied on to indicate the status of an object in the HMI.

The I/O Server shall read trend points according to the configured trend period, alarm points shall always be scanned and other information scanned only on an as-needed basis, i.e. when the page is displayed.

The I/O Server must perform read and write caching of data for a time configurable for each Device Driver. For Citect 1000ms is acceptable. This is to prevent data being read needlessly and therefore maximise I/O device communication bandwidth. i.e.; only one read is needed if the same I/O point is needed for multiple reasons. PLC polling times must ensure that implementation of a new PLC or device will not cause communication issues to any existing PLCs.

It must be possible to display other graphics pages by selecting screen targets, and to automatically display any screen based on the condition of a variable e.g. automatically call a particular graphic display when an alarm occurs.

User-configurable colours must be available and it must be possible to define colours as flashing between any two colours. When multiple objects on a page are configured for flashing then each object must flash synchronously.

The SCADA HMI screen configuration must have the capability to provide pop-up windows for trends, loops and device status pages.

All displays must include the page name, current login details, current time and date together with details of the last alarm that has occurred.

Reusable and uniform SCADA objects are to be used in SCADA. Moving animation is not to be used.

There is a requirement for the STP WAN to support communication channels for video feeds however this is an isolated system to the SCADA. The SCADA LAN within all STPs shall not to be used for cameras or CCTVs.

Update times in the Process Control System windows must not be affected.

If communications to a particular I/O point has failed for any reason, then wherever that data is displayed the SCADA must post a visual indication that the point is not valid.

6.11.3 Specification Documentation Requirements

6.11.3.1 Mouse/Cursor/Touch Points

The items that will be accessible via mouse/cursor/touch points shall be defined in the HMI User Manual document for the site. This definition shall include access to drives, valves, control loops, data, selections, sequences, pop-up windows, detail graphics and menus.

6.11.3.2 Trend Assignment

The criteria defining the parameters that will be assigned to trend pages shall be defined in the HMI User Manual specification.

6.11.3.3 History Assignment

The criteria defining the parameters that will be assigned to historical data logging shall be defined in the HMI User Manual specification.

7 QUALITY ASSURANCE, INSPECTION & TESTING

The Contractor shall demonstrate that all works comply fully with this specification and all associated Project Documentation. Refer to Appendix A for quick reference of delivery phases of Control Systems.

7.1 QUALITY ASSURANCE

The Contractor shall apply a quality assurance system accredited to ISO 9001:2000 for all works. The effectiveness of the quality assurance system and the Contractor's compliance with it shall be subject to monitoring by QUU and in addition, may be audited following an agreed period of notice.

The Contractor shall submit a quality control plan for QUU's review at the time of tender. The Contractor shall cooperate with QUU's nominated auditors during all stages of the works with respect to quality assurance matters.

Components and works shall be inspected and tested in accordance with quality control and assurance procedures nominated by the Contractor and accepted by QUU. The Contractor shall identify hold points for witnessing by QUU.

7.2 INSPECTION AND TESTING

QUU shall be permitted at all times free access to all parts of the Contractor's works including off site facilities, on-site work areas and storage facilities.

The Contractor shall supply all test equipment, tools and materials required and shall be fit for purpose, in good working condition and calibrated. Calibration certificates shall be maintained for all relevant equipment.

Only QUU supported versions of software programming licenses shall be utilised by the Contractor for software development, testing and site implementation.

7.3 INSPECTION AND TEST PLAN

The Contractor shall include typical Inspection and Test Plans (ITP's) in their tender documents. The ITP's shall list typical inspections and tests proposed for all elements of the works.

Prior to commencement of the relevant works the ITP's shall be customised by the Contractor for the project works and accepted by QUU. QUU and the Contractor shall sign off the final version of the ITP's, which, thereafter, shall form part of the contractual documents. The ITP's shall encompass the testing requirements of all relevant standards and statutory and regulatory requirements.

The Contractor shall be responsible for the planning and execution of all inspections and tests, with QUU having the right to witness any or all of the inspections or tests. The Contractor shall obtain QUU acceptance of ITP's prior to the commencement of any testing, print-off the

ITP work packs and produce them prior to the start of FAT and SAT. ITP's shall be completed and signed off progressively during the execution of the works.

ITP's and checksheets shall be completed at all stages of the project to demonstrate the control system hardware and software has been satisfactorily tested to meet all defined requirements whether or not witnessed by QUU.

Where appropriate, test and 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.

7.4 SOFTWARE FACTORY ACCEPTANCE TEST

7.4.1 Overview

A Control System Software FAT shall be prepared by the Contractor and submitted to QUU for acceptance prior to commencing the software testing. The document shall cover all of the control and monitoring functionality specified for the control system. The object of this document will be that when testing is complete, the control system including RTU's, PLC's, HMI's and SCADA will have all functionality simulated and tested as per the design documentation.

All control system software developed shall undergo rigorous software validation and verification to the accepted test plan. QUU may witness part or all of the software simulation tests.

Software FAT's are typically performed with the RTU/PLC processor and other HMI and controllers connected via temporary communication cables and network switches. The SCADA terminal and I/O server are also connected to the same communications network. The software code to simulate the functionality required generally resides in the RTU/PLC processor.

Software validation and verification is the full responsibility of the Contractor and all code and software shall undertake comprehensive in-house testing, inclusive of formal testing documentation, to ensure any testing witnessed by QUU can be carried out with relatively few and minor defects.

QUU will nominate which components of the testing will be witnesses and unless advised otherwise, QUU will witness all testing. All tests nominated to be witnessed by QUU shall be pre–tested by the Contractor and QA documentation completed. Records of all tests completed shall be available for QUU review at the time of witness the testing. QUU declining to attend witness testing does not relieve Contractor of the obligation to comprehensively test the software to the accepted test plan.

At the completion of the testing the Contractor shall compile a Control System Software FAT Test Report. All the test sheets fully completed and signed off shall be included in the test report and submitted to QUU within 5 business days of completing the testing. The Control System Software FAT Test Report should be accepted by QUU before the Integrated FAT commences, so there is no delay caused by Contractor closing out QUU review comments to the test report.

The Control System Software FAT Plan shall include but not limited to the following:-

- Overview and detail description of the software bench test setup and methodology
- Block diagram showing connections of all equipment included in the test
- Hardware and software revision recorded
- 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 to the project
- Individual Pump, Valve, standard subroutine deployment testing
- RTU/PLC code – test all modes of operation of each equipment device
- RTU/PLC code – sequence testing
- SCADA system testing
- Full bench test functional testing (including network communications)
- SCADA tags list(all points tested to the HMI screens)
- Alarm list
- Setpoint list – 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
- Performance – HMI screen update times
- Redundancy and failover

The Software Simulation Tests Plan must be logical, well-structured and be thorough. In addition the following guidelines shall be adhered to:-

- Contractor's software testing officer and the programmer shall not be the same person unless accepted otherwise by QUU prior to Contract award.
- All software shall be tested for compliance with the QUU accepted Functional Specification.
- All local HMI and SCADA configurations shall be tested for compliance with the QUU accepted HMI User Interface Manual.
- Updates to all Project Documentation required as a result of all simulation testing shall be the responsibility of the Contractor and any proposed modifications must be accepted by QUU.
- Project specific test sheets shall be prepared from the QUU accepted Functional Specification and HMI Operator Interface Specification documents.
- All alarm points shall be simulated to the HMI's alarm page as well as visual fault status on devices
- All trends shall be simulated to the HMI's and confirmed to be scaled per the I/O list parameters
- Every section and paragraph in the Functional Specification (which details functionality) must have a corresponding test sheet activity to confirm that the software fully conforms to the Functional Specification.
- All test sheets and test steps must clearly reference which section(s) and paragraphs of the Functional Specification they are validating.
- Software testing should not commence until QUU has accepted the Software Simulation Test Plan.

- The revision of the Functional Specification must be recorded on the test sheets.

The software simulation testing will comprise a major component of the works and is likely to require significant resources and time to complete for larger projects. Simulation software internal or external of the RTU/PLC shall be developed to undertake the testing.

- Simulation Function blocks used to emulate devices such as pumps, valves and varying tank levels etc shall incorporate realistic time delays to reflect process conditions as close as possible.
- All simulation software blocks shall be accepted by QUU prior to commencement of the functional testing.
- All temporary tagnames prepared for the simulation shall be identified in a unique manner so that it can be removed or disabled prior to FAT commencing.
- All simulation function blocks and code shall be kept within a separate subroutine and deleted prior to FAT commencing.

The Contractor shall be responsible for the setup and configuration of the complete control system testing environment inclusive of all Free Issued items (if specified) and required cabling. This test environment shall facilitate the testing of all RTU/PLC code and SCADA systems functionality.

The Contractor shall also verify that all QUU free issued items that have been delivered are free of faults prior to testing commencing.

7.4.2 RTU/PLC Code Testing

Where individual RTU/PLC's are of similar I/O and setup, a complete software test of each type is sufficient. For individual pump code testing, the full RTU/PLC, including all remote I/O drops must 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 feedback of equipment I/O (e.g. Pump Run output can trigger the Pump Running Input via software code).

The individual device's software code test must contain, as a minimum, the following:

- Full inter PLC I/O (Master to Pump PLC's etc)
- All equipment start/stop sequencing tested
- All equipment start and run interlocks tested
- All equipment modes, alarms and events tested including setpoints and mode selection.
- All operator commands i.e. start, stop resets and setpoints shall be tested including confirming boundary limitation for analogue setpoints.
- Hardware redundancy and communication link status for all devices configured and validated.
- Test how equipment failures and remote I/O failure modes affect operation of other process control equipment

7.4.3 Functionality Testing

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

Full sequence testing will be undertaken for both dry weather and wet weather scenarios to confirm start-up/shut-down/ 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, verification and validation must be carried out on all foreseeable failure modes as detailed in the operating protocol and as a minimum, the following must be fully testing:

- Redundancy testing of SCADA Servers(where applicable)
- Testing of all RTU/PLC failure modes
- Test programs to provide simulation of well levels, flow rates and pressure as well as 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) to ensure correct shutdown, duty rotation and start up occurs.
- Failure of ancillary equipment (valves, brakes, cooling pumps etc) required for equipment operation. All equipment that is an interlock must be tested to ensure system reacts correctly to equipment failure.
- All 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
- The Contractor must fully document how emergency operation of one drive under manual mode can be achieved.
- Transitions between all modes.
- Faults occurring during mode transitions

7.4.3.1 Pre-FAT Functionality Testing

The Contractor shall perform and record all functionality testing prior to QUU witnessed testing. QUU shall request evidence of test results prior to commencement of bench test witnessing.

7.4.3.2 Functionality Testing Template

The following is representative of QUUs minimum requirements for functional testing. Functionality test sheets shall describe the exact method of testing so as to replicate the tests with repeated results.

The Contractor shall provide test sheets with the minimum of the following criteria;

The header of each page clearly identifies;

- the title of the Functional Specification under test and revision,
- the document name,
- Document revision number
- Project name and QUU Contract number
- Date

The footer of each page indicates;

- the document number
- the page number of the total number of pages

The testing shall be broken down into sub-heading clearly listing,

- the Functional Specification section number and title reference
- the specific tests being carried out under the sub-heading
- Tagname of equipment under test

The tests shall specify the following within the order specified;

1. The "Prerequisites" - all conditions required before the action is to be performed. All setpoints values and input values shall be specified.
2. The "Test Action" - the operator action/s required to trigger the test
3. The "Test Number" – the number of the test which falls under the overall section title
4. The "Expected Result" – the test's pass/fail criteria.
5. The "Actual Value" – for all non pass or fail results, all resultant values shall be recorded
6. Pass Checkbox - Each predicted result shall be individually listed with its own pass check box. The Contractor shall initial each test upon a successful result. Failures are not to be marked on this test sheet. Defects shall be noted on a Defect Register with reference to the exact test number and attached to the test sheet. Once fixed and witnessed by QUU, the test sheet shall be updated with a pass date and time.
7. Comments – any unanticipated criteria or conditions shall be noted in this space. If space is insufficient, the Contractor shall insert a reference note. Reference notes may be listed at the end of the test sheet.

7.4.3.3 Software Code Simulation Testing

Software simulation and verification may not be required where the Contractor will be implementing RTU/PLC and SCADA software that has been copied from an existing commissioned QUU site and the Contractor is only making minor changes under the Contract. In this case only the changes made to the software require simulation testing.

Refer to section 8.4.11 Software Test Strategy for the extent of the software simulation required for the project.

7.4.3.4 User Acceptance Testing

To conclude the Functional Testing, the Contractor shall provide User Acceptance Testing. QUU will propose realistic scenarios to the Contractor that were not already covered in the functional testing. The Contractor shall record all proposed test scenarios and results at the end of the functionality test sheets. Failure to successfully perform to a proposed realistic scenario shall be recorded and classified as a defect.

The Contractor shall allow for additional test requests by QUU during each phase of the testing. There should not be more than 5% of the agreed test plan for each phase.

7.4.4 Software Simulation Testing Notification

The Contractor shall provide written notice advising QUU not less than ten (10) working days prior to the commencement of software simulation test commencing so QUU can arrange to witness the testing.

QUU will not witness any testing until the software simulation test plan has been reviewed and accepted by QUU.

The Contractor shall issue a time schedule for the daily testing activities to demonstrate that all proposed tests can be executed in the time allocated.

7.4.5 Software Simulation Test Report

At the completion of the software simulation testing the Contractor shall submit a Software Simulation Test Report for QUU review. QUU may request further inspection or witness testing to demonstrate punch list items have been closed out satisfactorily.

7.5 INTIGRATED FACTORY ACCEPTANCE TEST

A Control System integrated hardware and software FAT Plan shall be prepared by the Contractor and submitted to QUU for acceptance prior to performing any FAT tasks. The document shall cover the testing of all the control and monitoring functionality required by the control system. The object of this document will be that when testing is complete, the control system including RTU, PLC, HMI terminals, SCADA and electrical equipment will have all functionality tested as per the design documentation. The FAT shall be comprehensive and executed thoroughly so as to reduce SAT to the absolute minimum where practical.

The control system FAT plan must be integrated with the FAT plan for other significant items of electrical equipment such as switchboards, variable speed drives, UPS's and battery chargers. Refer to the QUU technical specifications for specific electrical equipment FAT plans

The control system FAT shall use the actual RTU, PLC, communications device, HMI Terminals and SCADA hardware where possible and will simulate all field electrical equipment and instruments not connected for the test. This means the FAT must be done with the switchboards and other electrical equipment temporarily connected in the Contractor's work shop. Where the equipment is installed in a demountable switchroom the FAT shall be executed with the equipment permanently installed and all inter-panel wiring permanently connected in the switchroom prior to delivery to QUU site.

Undertaking any part of the FAT on QUU sites is not accepted. The Contractor's proposed equipment delivery schedule must allow for a complete FAT on equipment prior to delivery to QUU site. The FAT shall be completed to the satisfaction of QUU before the equipment shall be released for delivery to site.

The FAT Plan document shall include, but not limited to the following:-

- Steps for the preparation, configuration and start-up of all equipment that will be used to perform the required testing.
- Test the complete functionality required of the equipment as per the Functional Specification document.
- Checkbox columns required for testing. These columns will include the initials of the tester and the date of the test.
- For items of equipment that have identical testing routines, it will be acceptable to provide one general testing routine checksheet that is applicable for multiple devices. The Contractor shall provide a separate checksheet for each individual device.
- Where RTU, PLC, HMI or SCADA is integrated into the project, the testing documentation must include all configured RTU/PLC and HMI functionality as well as SCADA functionality. This includes all required alarm points, trend display and report functionality must be included as a list item in the testing documentation.
- At the end of the testing process, all setpoints, equipment settings and software and firmware revisions must be recorded.
- Complete circuit checks per cubicle (including control cubicles and load centres) of each cable, termination and circuit components against the drawings. These drawings shall be marked off accordingly and erroneous designations corrected to the satisfaction of QUU.
- All Communication links shall be tested between RTU/PLC's, SCADA, soft starters, VSD's, protection relays and all other devices with communication ports shall be tested.
- Radio communication links to remote devices shall be established and all communications signals tested between devices and networks. The QUU test facility shall be used as required for testing to remote SCADA networks.
- All RTU/PLC hardware configuration, programs and SCADA configuration shall be thoroughly tested.
- Test communication to all devices in the control system network
- I/O list
- Hardware alarm tests
- Physical I/O test, including full range testing of all analogue signals (0%, 50% and 100% values recorded when injected with 4mA, 12mA and 20mA respectively).
- All equipment SCADA point tested, including analogue range and engineering units confirmed.
- All communication faults and RTU/PLC errors shall be alarmed in SCADA.
- Test all RTU/PLC local and remote I/O failure modes

7.5.1 RTU/PLC Hardware Testing

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

- Removal of each hardware card shall result in a hardware alarm in the SCADA, the CPU indication and in the hardware configuration software
- Validate the hardware RTU/PLC time/date is updated from SCADA and that the correct time zone is selected.
- Failure of field bus equipment is recognised by the bus controller and enunciated accurately on the SCADA, programming and field bus software. The Bus Failure (BF) indication LED is available on some makes of CPU.
- The Contractor and QUU's commissioning engineer shall verify that there are no software failures (SF's) present in the diagnostic buffer or the engineering software
- All non-volatile memory is retained on removal of supply power. All initial values and critical setpoints are retained
- The CPU Battery Low alarm is functional to SCADA, local HMI and programming software
- Loss of Remote I/O racks must be detected, alarmed and handled in accordance with the system criticality and technology constraints.
- The Contractor must test the hardware and software on the same version of software as used on site. As such the Contractor shall verify that the software versions and current hardware version do not present any issues eg. Loss online monitoring to RTU/PLC, or unstable PID control, or storm communications broadcasts.
- All LEDs and displays on the hardware are functional
- Visual damage to equipment enclosures , electronics, bent pins, broken plugs, interface cables
- Conformal coatings checks where required

7.5.2 Point to Point Testing

This testing shall verify that the control panel has been wired as per the schematic. It also ensures that the supply power to the PLC has the correct polarity, all channel fuses are sized correctly and all over voltage devices are functional. These checks help avoid accidental damage to control systems equipment from incorrect wiring.

During the FAT a complete as manufactured set of drawings shall be used to highlight the power, control and instrument loops and wiring for the point to point testing of the equipment connected for the FAT.

The point to point wire testing records shall be maintained by the Contractor and is typically a set of schematic drawings. The Contractors electrical tester is to systematically "point to point test" each control circuit wire for continuity and whilst highlighting each tested wire in the schematic with a light green highlighter. This set of schematic drawings is to be clearly labelled as the "point to point test" drawing set. Each sheet is to be stamped, dated and signed by the Contractor's electrical tester and the signed copies of these drawings shall be submitted to QUU with the FAT Report.

7.5.3 Input / Output Testing

At the test, the RTU/PLC and SCADA is powered and operational. This testing verifies that each analogue channel, each digital port and each output relay, in the in the control panel is fully operational. It also verifies that values are scaled as expected within the RTU/PLC. Note that scaling is not to be performed within the SCADA.

Prior to the commencement of FAT functional testing the Contractor shall load the relevant software code into the RTU/PLC, and local HMI terminals and SCADA server hardware. If the SCADA project is to be later integrated into an existing, larger SCADA project, the Contractor shall setup a temporary SCADA server/client machine using the Contractor's hardware and development license. QUU will not issues licenses to the Contractor for FAT.

These tests will allow the Contractor to function test the hardware and electrical equipment from the field terminals through to the SCADA and local HMI. The Contractor is responsible for pre-testing and function testing prior to the site delivery with the site software loaded in the equipment. The functional testing includes confirming that all devices and equipment are fully configured for the site application.

All control and power circuits shall be energised at their operating voltage from a temporary supply. Field pushbuttons, switches and indicating lights shall be temporarily installed, as required, to fully simulate all field input and output devices. Each feature of the circuit and / or sub-circuit shall then be tested by the Contractor, including the satisfactory operation of all actual field input and output devices. Where practical Functional testing shall also be carried out with instrumentation temporarily connected.

Each starter shall be fully programmed and tested by the Contractor while connected to a suitable three phase motor capable of demonstrating the functionality of the starter. Guidance shall be sought from the original equipment manufacturer regarding the site specific requirements for all user adjustable parameters. The provision of all equipment including temporary cabling, fixtures and fittings required for the test shall be the responsibility of the Contractor. The Contractor shall provide a fully documented parameter list for each drive showing default parameter settings and site specific parameter settings. The Contractor is responsible for programming the motor starter units to meet all site specific functionality and operating conditions before delivery of the equipment to the site.

7.5.3.1 Analogue Checks

Analogue loops shall be injected with a variable input signal equivalent to its specified input and the signal shall be varied over its entire range in both a positive (low to high) and negative (high to low) direction to test the operation of associated indicators, controllers and recorders. Where practicable, and without causing damage to connected equipment, over and under-range shall also be tested. In the case of controllers, outputs shall be monitored and the set-points checked for correct operation, including associated process alarms. As a minimum analogue channels shall all be tested to 0%,25%, 50%, 75% and 100% of span. The Contractor testing officer shall record the engineering units and associated milliamps. The exact method of testing shall be recorded eg. Simulated through current injection or simulated value within the flow transmitter. Current Injection meters shall be calibrated and a copy of the calibration certificate included within the FAT report.

7.5.3.2 Control Circuit Functional Checks

The control circuits in the switchboard(s) shall be checked for correct function by the Contractor and marked off on a record set of schematic drawings. These drawings shall be amended to reflect the final connections of the switchboard(s) as despatched from the workshop. The record set of schematic drawings must be clearly labelled as "control circuit

functional check" drawings. Each sheet is to be stamped, dated and signed by the Contractor's electrical tester and the signed copies of these drawings shall be submitted to the Superintendent.

7.5.3.3 Summary

Where QUU carries out spot checks on the tested equipment and/or test records and discovers anomalies or inconsistencies, the Contractor shall retest the equipment unless agreed otherwise by QUU.

As part of the equipment functional testing, the Contractor shall provide three (3) sets of electrical drawings as follows:

- 'Point to point test' record drawing set, with each page stamped, signed, dated and clearly labelled;
- 'Control circuit functional check' drawing set, with each page stamped, signed, dated and clearly labelled; and

As Built drawing set, with each page stamped, signed, dated and clearly labelled.

7.5.4 Factory Acceptance Testing Notification

The Contractor shall issue a time schedule for the daily FAT activities to demonstrate that all proposed tests can be executed in the time allocated.

The Contractor shall provide written notice advising QUU not less than ten (10) working days prior to FAT commencing, so that QUU can arrange to witness the testing.

QUU will not witness any testing until the control system FAT Plan has been reviewed and accepted by QUU.

7.5.5 FAT Report

At the completion of the FAT the Contractor shall submit a FAT Report for QUU review. The equipment shall not be packaged and delivered to site until QUU has accepted the FAT Report and all outstanding punch list items identified at the FAT have been closed out to QUU's satisfaction. QUU may request further inspection or witness testing to demonstrate punch list items have been closed out satisfactorily.

The FAT Report typically contains and not limited to the following documents:-

- Marked up "redlined" As Built drawings (in electronic PDF and paper versions). These drawings shall have the following information clearly marked on each sheet:
- Contractor's Company Name
- Contractor's Company Electrical Licence No.
- Electricians Name
- Electricians Signature and Date
- Electrician License No.
- Complete set of signed and clearly labelled and marked up check drawings following point to point testing;

- Complete set of signed and clearly labelled and marked up check drawings following control system functional check testing;
- Complete set of signed switchboard compliance test sheets;
- I/O list – signed to indicate tested through to the HMI screen
- HMI screens printouts green lined and signed to indicate tested all display animations and navigation controls.
- SCADA Point list – each control and status point initialled to indicate tested to the PLC
- Certificate of compliance for all electrical equipment
- Protection setting parameter listing of all IED's(all changes from factory defaults indicated)
- Protection setting parameter listing of all VSD's and soft starters (all changes from factory defaults indicated)
- The report shall also require evidence that;
    - There are no PLC/RTU hardware faults
    - All hardware alarms are operational
    - Record all current memory usage and CPU usage as per section 6.8.2

7.6 SITE ACCEPTANCE TESTING

The Contractor must gain Control System Access Authorisation which is granted by QUU before accessing any live control system which is in service. All site modification and testing works on control systems in service shall be performed under the PRO396 Control Systems Change Management Procedure and FOR603 Control System Change Management Form which shall be completed by the Contractor. The onsite control system modifications and testing must be completed under controlled and fully managed conditions.

Prior to SAT commencing the Contractor shall ensure the following:-

- All bench test simulation code has been removed
- All I/O has been reinstated into the controlled copy of the tested code
- The system has been checked for diagnostics errors.
- On Brownfield sites, all code is submitted to QUU via sharefile for transfer to the site backup location.
- The Contractor is authorised by QUU to make changes to existing control systems assets
- Change Request documentation has been accepted by QUU.

7.6.1 Post Installation Inspection

The control system hardware site installation works shall be visually inspected by the Contractor for:-

- Correct installation in accordance with appropriate drawings;
- Acceptable workmanship quality;
- Accessibility for operations and maintenance; and
- Compliance with QUU specifications

The Contractor shall produce inspection sheets to demonstrate that all installed equipment has been thoroughly inspected.

The Control System Site Acceptance Tests (SAT) shall be executed after the control system hardware and other electrical equipment has been installed on the site and equipment inspections have been completed.

The SAT generally must be completed prior to commencing the commissioning of the control systems.

SAT typically involved simulating all field equipment (at the field device) where practical to demonstrate functionality of the control system as per the Functional Specification. The SAT is distinctly different to the commissioning phase of the project. QUU defines the commissioning phase commencing when the control system and other mechanical and electrical equipment are first introduced to the normal service conditions as an integrated system.

7.6.2 Control System SAT Plan

The Contractor shall develop a Control System Site Acceptance Test (SAT) Plan specific to the site. The Contractor shall propose the SAT in accordance with routine testing as per relevant Australian Standards.

The SAT Plan shall include the inspections, tests, strategy and include the associated blank test and inspection check sheets. The plan shall clearly define the logical sequence and structured testing of the complete installation including SCADA system, RTU/PLC's, HMI terminals and all field devices in accordance with the issued drawings and other accepted Project Documentation. SAT should not commence until after QUU has accepted the SAT Plan.

The Control System SAT requires the actual RTU, PLC, HMI's and SCADA hardware to be installed and ready for testing. The SAT generally requires all instrumentation and other electrical equipment available for the test. Simulation of field device operation is to be absolute minimal and only accepted where a device cannot be observed to be functioning without simulation.

The SAT Plan shall incorporate the following tests as a minimum:-

- SCADA testing of communication interfaces to all remote RTU/PLC's and HMI Terminals
- SCADA testing of communication interfaces to QUU telemetry system where applicable
- SCADA testing for remote(offsite) network access
- Testing field instrument loops and status correctly displayed at SCADA terminals
- Testing of all field devices from the field through to the QUU Telemetry Systems Control Room;
- All PLC hardware configuration and I/O checking is performed.
- Full redundancy and failover testing for PLC's, servers, networks and UPS's.
- All settings, setpoints and software and firmware revisions are recorded.
- Completion of I/O Lists

7.6.3 I/O Testing - Implementation and Test Plan

All I/O shall be tested and recorded by the Contractor. The I/O test sheet shall clearly state the exact method used to verify the I/O point without any ambiguity.

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 reason.

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

The I/O Checksheets shall as a minimum, contain the following parameters;

- RTU/PLC Number - eg. PLC3
- Rack Number – eg. Rack 0
- Rack Location
- Slot Number – eg. Slot 8
- Card Type / Model –eg. IC694MDL655CA
- Brief Card Description - eg. DI

The Digital I/O points under test shall include;

- Channel Number
- I/O Address
- Equipment ID
- Description of the equipment and its attribute eg. Plant Bypass Valve Remote-mode selected
- Tagname
- Digitals I/O Off state – eg. Stopped
- Digital I/O On state – eg. Running
- Drawing Number
- PLC checks - scaling, filtering, alarms
- Local HMI check - statuses, alarms, trends
- SCADA server check – statuses, alarms, trends
- Comments

The analogue I/O test sheet shall take the form individual instrument / device test sheets. Each analogue signal shall be tested for the full range of operation.

The analogue channel or instrument under test shall include as a minimum;

- Channel number
- I/O Address
- Equipment Tagname
- Description
- Tagname
- Analogue Range – Reading in EUs at 0mA (Out of Range alarm)
- Analogue Range – Increment reading in EUs at 4mA (0%)
- Analogue Range - Increment reading in EUs at 8mA (25%)
- Analogue Range - Increment reading in EUs at 12mA (50%)

- Analogue Range - Increment reading in EUs at 16mA (75%)
- Analogue Range - Increment reading in EUs at 20mA (100%)
- Analogue Range - Increment reading in EUs at 24mA (Out of Range alarm)
- RTU/PLC code reading – raw value, scaled value, filter times, associated alarms
- Instrument local reading (for each increment) - scaled value, engineering units
- Local HMI check – scaled value, engineering units
- SCADA server check – scaled value, engineering units, trending
- Drawing Number
- Comments

7.6.4 Site Functional Testing

The Contractor shall perform the complete site functional testing in the presence of QUU's nominated site personnel.

Functional test results shall not to be embedded within the Functional Specification.

The functional tests shall include but are not limited to the following:-

- Functionality testing of equipment including pumps, valves, fans etc under all modes of operation from both local HMI and SCADA terminals;
- Any functional testing that was not physically possible to be tested during FAT
- Functionality testing of the control system backup and changeover system;
- Failure modes and process plant recovery;
- Functionality testing of all 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 will be performed on all plants and pump stations to ensure that all equipment will return to operating status following a power blackout without generating alarms or callouts to operators;
- Operational sequence and interlocking checks;
- All control modes shall be tested including back–up and emergency control mode for pump stations.

7.6.5 Specialised Equipment

Any specialised control system equipment not covered by the SAT requirements disclosed in this specification shall be fully tested in accordance with the manufacturer's directions and as directed by QUU.

7.6.6 Test Failure

Any equipment supplied by the Contractor that fails the SAT or has a defect shall be repaired or replaced by the Contractor. All inspections and tests which are affected by the rework shall be repeated by the Contractor.

7.6.7 Test Equipment

All test equipment shall be supplied by the Contractor and certified and traceable to an applicable standard. A list of test equipment along with copies of calibration test certificates shall be kept at the site and must be available for QUU to review upon request during the SAT.

The test equipment listed shall have a standard of at least three (3) times better accuracy than the Manufacturer's stated accuracy for the equipment to be tested and shall be calibrated within six months of the test date.

The electrical equipment and the electrical installation works shall be thoroughly inspected and tested before energising in accordance with QUU specifications and Australian standards.

A record of inspection and test results shall be maintained by the Contractor and will form part of the project handover documentation.

Checks shall include the correct QUU asset tag number, range, voltage and nameplate as a minimum. Any deviation shall be bought to the attention of QUU and the supplier.

7.6.8 Test Requirements

The Contractor shall develop a SAT Plan that includes a complete set of test check sheets that clearly defines the logical sequence and structured testing of the equipment in accordance with the Project Documentation. The SAT plan shall be site specific and requires QUU's acceptance prior to commencement of the SAT. The Contractor shall complete the SAT in accordance with accepted SAT plan and to the satisfaction of QUU.

A project specific Site Acceptance Test Procedure- Checklist shall be prepared by the Contractor. The check list shall be completed by the Contractor on the day of every planned SAT. The Contractor shall review this checklist prior to SAT to ensure all proposed testing can be completed on the day.

The Contractor shall provide all permits, access, resources, tools and equipment to undertake the SAT. QUU will only be required to attend the site to witness the SAT. QUU may not witness all tests, and will inform the Contractor on the day of the testing as to what tests will be witnessed. QUU electing to not witness the SAT does not relieve the Contractor to undertake the SAT as per the QUU accepted SAT plan. Unless stated otherwise QUU will witness all SAT activities.

7.6.8.1 Cables

Before applying power to the control system equipment all cable inspection and tests must be complete and records available at the site for QUU to inspect.

The cable ITP's shall detail the exact test requirements for all control and communication cables. As a minimum requirement, the following copper cable tests shall be completed:

- All cables and wiring shall be tested for continuity on each core.
- All cables and panel wiring insulation resistance.

- The test voltage shall be compatible with the control cabling being tested.

Note: Sensitive electronic components shall not be connected during copper cable insulation testing.

For fibre optic cables all the fibre cores shall be tested with an ODTR for length, transmission anomalies, and end-to-end attenuation. Results are to be recorded and available for QUU inspection in the form of hard-copy printouts.

The control and communication cable ITP shall also include the following:-

- Check all cable terminations are in accordance with termination diagrams. Termination diagrams shall be marked up, signed and issued to QUU as evidence of the tests.
- Check cable number label against cable schedule. Cable schedules shall be marked up, signed and issued to QUU as evidence of the checks.
- Check tightness of all terminations.

Complete circuit checks for site installed cabling against the termination drawings. The termination drawings shall be marked off accordingly and erroneous designations corrected to the satisfaction of QUU.

7.6.8.2 Earthing and Bonding

The Contractor shall test all control system equipment earthing to any existing earthing system. Tests shall check that resistances are within acceptable levels.

7.6.9 Equipment SAT Plan

The Control System FAT plan must be co-ordinated with the Equipment SAT Plan for other equipment items such as switchboards, motor staters, instruments etc. Refer to TMS1200 for SAT requirements of electrical equipment and refer to TMS1201 for SAT requirements of instrumentation.

For large projects the Equipment SAT plans shall be provided by the Contractor for each equipment type in addition to the site specific Control System SAT Plan. For smaller projects such as new or refurbished pump stations the Equipment SAT plans and Control system FAT Plan may be combined into a common document called the Integrated SAT Plan.

The Equipment SAT Plan(s) shall make reference to the Control System SAT Plan.

QUU may require further site testing over and above the accepted SAT Plans to confirm that all equipment is tested and inspected thoroughly.

QUU may witness all or only selected site tests and may audit the records of tests during the SAT. All test sheets shall be completed during the testing activity and maintained up to date and made available for QUU to review at the site upon request.

Where QUU does not witness a site testing tasks, this does not relieve the Contractor from executing the SAT as per the accepted SAT Plans.

7.6.10 Control System Cut-over Plan

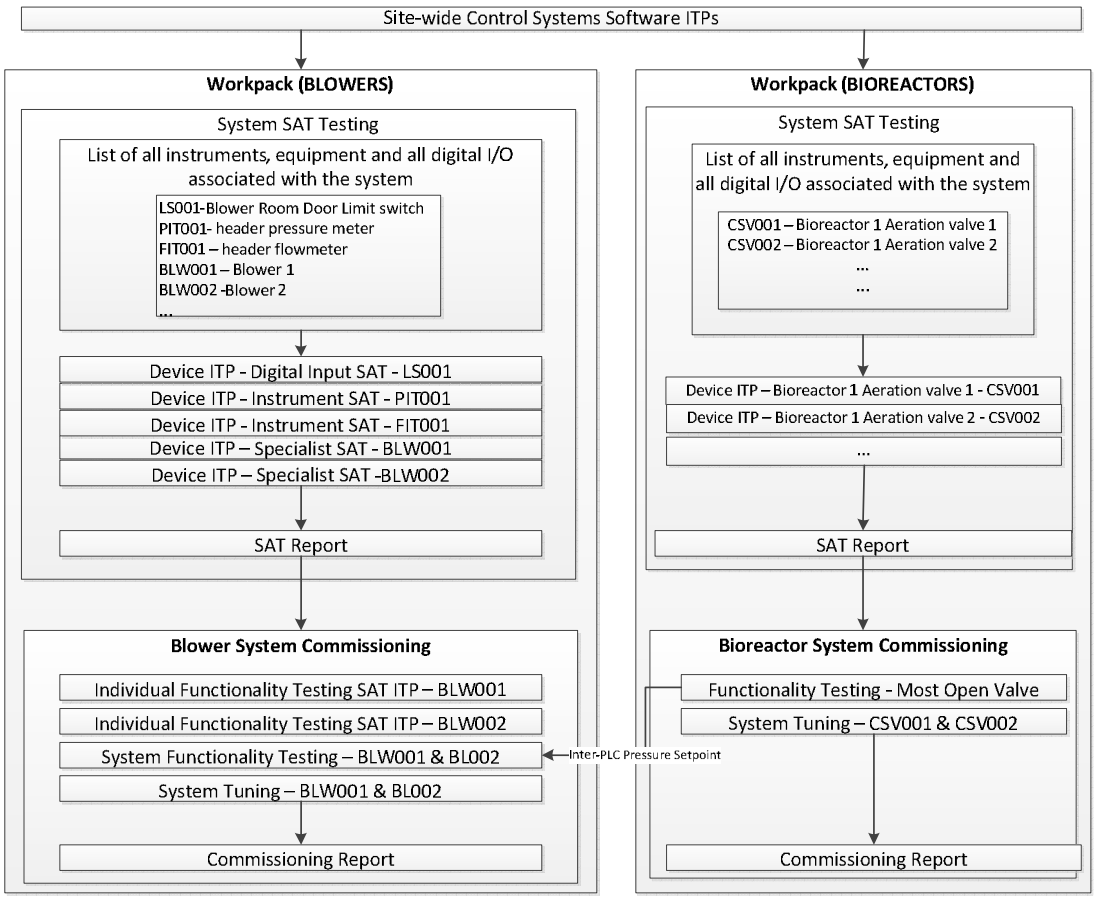
On complex or larger projects the Contractor shall prepare a Control System Cut-over Plan, refer to section 8.5.1 Control System Changeover Plan. This plan shall describe the step by step procedures that the Contractor shall follow to cutover from the existing to the new control system. All pre-conditions, hazards, risk control measures and tasks required shall be listed without ambiguity. The test 'Pass' criteria shall be stated in full on the supporting test sheets. The tests results shall be fully traceable and replicable.

The Control System Cut-over Plan and ITPs for large projects shall be subdivided into system or area specific work packs.

The system work packs shall list all associated digital I/O and all instruments and devices associated with the system. The listing shall also include all required inter-PLC required data.

The device ITP's 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. The completed testing documentation for each system shall be scanned and submitted in individual work packs at completion of the testing and commissioning tasks.

The following workflow provides a typical example for a control system work pack grouping for SAT and Commissioning.



7.6.11 SAT Report

The Contractor shall provide a SAT report at the completion of the SAT to QUU for acceptance. The SAT Report shall contain all records of testing undertaken including completed ITP's, check sheets, records of instrument calibrations, test equipment calibration certificates. All test, inspection and check sheets shall be signed and dated by the Contractor's testing officer. The name and electrical license number of the testing officer shall be provided on each sheet. The test records shall indicate the QUU Equipment tag name of the instrument, cable or other device.

The SAT Report typically contains the following documents:-

- For switchboard and associated electrical drawings, marked up and updated "AS CONSTRUCTED" drawings (in both electronic native AutoCAD and PDF versions, and Hard-copy paper versions). These drawings shall have the following information clearly marked on each sheet:
  - Company Name
  - Company Electrical Licence No.
  - Electricians Name
  - Electricians Signature & Date
  - Electrician License No.
- Drawings shall be provided in both electronic PDF and hard-copy paper versions. The 'AS CONSTRUCTED' drawing shall have the certification block signed on behalf of the Contractor by a Registered Professional Engineer of Queensland. The drawings shall have the following information clearly marked on each sheet:
  - Constructor Company Name
  - Site Supervisors Name and accreditation (if any)
  - Full name of RPEQ (clearly printed), including RPEQ registered number
  - Company name of the RPEQ signatory
  - RPEQ Signature and date signed
- A certificate of AS3000 compliance, signed by the electrical Contractor, must also be supplied with the As-Constructed drawings, certifying that the construction complies with the design drawings and represent an accurate record of the works as constructed;
- Asset / Equipment Lists
- Certificate of compliance for all electrical equipment;

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

7.7 COMMISSIONING

The Contractor shall be responsible for the final commissioning of the completed control system works unless specified otherwise in the Project Documentation. In addition the Contractors scope may include plant start-up assistance.

The Contractor shall provide all special tools, software and materials required for commissioning including calibrated test equipment, software and technical support from equipment suppliers.

7.7.1 Commissioning Plan

For new sites a Commissioning Plan shall be prepared by the Contractor and submitted to QUU for acceptance prior to performing the commissioning activities.

For existing sites where replacement of the control system hardware or switchboards or other equipment is required the Contractor shall submit a Changeover Commissioning Plan. The plan shall detail how the existing control system will be disabled and removed from service and the new control system and equipment will be put into service. The plan details timeframe for the changeover and detail steps required to commission the new control system and equipment. The SAT and the commissioning activities may also have to be integrated and run concurrently so that the facilities can be brought online within the allowed cut-over timeframe window.

The Commissioning or Cut-over Plan shall be accompanied with all associated blank test and inspection check sheets that are project specific and proposed to be completed during the site works.

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 QUU
- SAT Punch list items have been closed out to QUU's satisfaction.
- Commissioning Plan is accepted by QUU

7.7.2 Functionality Testing

All departures from the approved Process Control Narrative and Functional Specification documents shall be immediately brought to the attention of QUU during SAT and Commissioning. All approved changes to functionality shall be updated in the Process Control Narrative, Functional Specification, SAT Plan, Commissioning Plan and ITPs.

7.7.3 Commissioning Report

At the completion of the commissioning phase the Contractor shall provide a final Commissioning Report that is a compilation of all commissioning records typically including inspection and test records generated during the commissioning works.

7.8 PROOF OF PERFORMANCE TESTING

7.8.1 Proof of Performance #1:

Proof of Performance testing shall be undertaken by the Contractor at the completion of the commissioning of all equipment and shall be for duration of 7 days. The Contractor shall be responsible for analysing performance and preparing a report to validate the functionality of the system under normal process conditions or dry weather conditions.

7.8.2 Proof of Performance #2:

Proof of Performance testing shall also be undertaken by the Contractor in the 12 months warranty period after a significant process or weather event. The Contractor shall be responsible for analysing performance and preparing a report to validate the functionality of the system under significant process or wet weather conditions.

8 DOCUMENTATION

8.1 OVERVIEW

The Contractor shall provide all documentation for the control system in accordance with the Project Documentation and the Supplier Data Requirements List (SDRL). The SDRL also nominates the delivery schedule of the documents.

Note that some documentation items identified on the SDRL shall be prepared and submitted to QUU with the Contractor's bid proposal.

8.2 DOCUMENTATION FORMAT

All documentation submitted to QUU shall be in the native formats (i.e. Word, Excel etc) as well as PDF format to allow QUU to easily review and collate comments.

8.3 PROGRAM OF WORKS AND SCHEDULING

The Contractor shall provide 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 Tender Proposal.

After Contract award the program shall be updated to indicate resources nominated to each task and base lined from the date of contract award. The critical path of the project shall be clearly identified. The program shall be updated by the Contractor with task percentage completed for the duration of the project and submitted to QUU for information with each project progress reports. The frequency of project progress reporting required will be specified in the Project Documentation.

The Contractor's delivery program shall provide a detailed breakdown of works. The breakdown of elements must be aligned with the Design Management Plan and must have consideration for stakeholder constraints and the procurement of any long lead time items.

Note: QUU require 10 business days to review any document submitted by the Contractor for review. The program must allow for this constraint and must 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 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
  - As Built Documentation submitted(back drafted)
  - O&M Manuals
  - Training

8.4 DESIGN DOCUMENTATION

8.4.1 Drawings

The drawings required to be prepared by the Contractor are nominated in the SDRL and other Project Documentation. The drawings prepared by the Contractor shall use QUU standard drawing template and all cross referencing on drawings shall use QUU assigned drawing and document numbers.

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

Should any deviation from the contract drawings and/or specifications be deemed necessary by the Contractor then written details of such deviations, and the reasons for them, shall be submitted for QUU acceptance. No departures from the Project Documentation shall be permitted without written acceptance from QUU.

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

8.4.2 RTU/PLC I/O List

The RTU/PLC I/O List is a document listing 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, tagname, equipment description, equipment ON/OFF states, analogue range in engineering units, loop and / or RTU/PLC termination drawing.

The RTU/PLC I/O List shall be included within the Control Systems Administration Manual. The list shall be provided as a Microsoft Excel document.

8.4.3 Equipment Lists

The Equipment Lists shall indicate all control system hardware devices and software licences supplied for the project. It includes equipment quantities, manufacturer and model number of the equipment. Firmware version must be specified where applicable. Information must be adequate to be able to order replacement equipment from the list.

The Equipment lists shall include, however not limited to the following:-

- Instrument List - lists instruments and nominates types, name, area, process, P&ID drawing reference, manufacturer, protocol, signal type, operating voltage, engineering unit, zero range, full range, Fieldbus address, Fieldbus configuration file name and version, comments.
- Drives List – lists power rating and starter type for each motor as well as SLD's and schematic drawings for the motor starters. For electronic motor protection relays it shall nominate Fieldbus address, Fieldbus configuration file name and version and comments.
- PLC, HMI and Network Switch Part Numbers List – All PLC parts shall be grouped under each rack and each entry shall include; Rack number, Slot number, Part Number, Serial number, Firmware revision, and Part number release/cancellation/discontinuation dates.

8.4.4 Datasheets

Datasheets shall be provided for the following equipment but not limited to:-

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

- PC's
- HMI Terminals

The data sheets must indicate the QUU asset tag number and list all pertinent technical data relevant to the equipment.

Vendor generic data sheets can be accepted where information not applicable to the equipment supplied is indicated with strike thru text or some other suitable method.

8.4.5 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.

8.4.6 SCADA Point List

This document provides a list of data points configured for communications between the 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.

8.4.7 Setpoints List

This document provides a list of all 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.

8.4.8 Process Control Narrative

The Project Documentation may call for the Contractor to develop a Process Control Narrative (PCN) which is also referred to as a Functional Description. The document shall describe the operation of the process for each plant area. This is typically a plain English description and may take a number of different forms and styles depending on the process or

plant areas being described and will not necessarily take into account the particular control system hardware and software being used to perform the required control system operation.

The PCN document must be reviewed and accepted by QUU before the Contractor can finalise the Functional Specification. The PCN shall complement and be in alignment with any P&ID drawings for the project.

The Contractor shall engage an RPEQ Process Engineer for approval of the PCN before issue to QUU for review.

In all cases, the PCN shall reference the associated P&IDs and revision numbers of the drawings must be listed in the PCN.

8.4.9 Functional Specification

The Contractor shall be responsible for the development of the site specific control system Functional Specification relevant to the Contract scope of works. This includes all PLC functionality. The document shall be derived from the Process Control Narrative. The document shall be developed by the Contractor after consultation with QUU stakeholders or third party stakeholders nominated by QUU.

The Functional Specification shall be written by the Contractor to incorporate the specific detail required for configuration and implementation of the particular Control System being used to perform the control system logic.

The control and monitoring features of the control system outlined in the Functional Specification must be in alignment with the PCN document and is the Contractors responsibility to ensure this alignment between the documents.

The Functional Specification should be accepted by QUU prior to control system configuration work being carried out.

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

Refer to TEM514 Typical Functional Specification Template (Complex Process). A Complex Process is considered any Control Systems on an STP site.

Refer to TEM515 Typical Functional Specification Template (Standard Process). A Standard Process is considered any Control Systems on a network asset site.

8.4.9.1 Functional Specification Guidelines

For uniformity across all QUU sites, the Contractor shall follow the minimum guidelines stipulated in the proceeding section when developing a Functional Specification document.

8.4.9.2 Purpose

The objectives of the Functional Specification shall be as follows:-

- It is a reference document suitable for use by operation and maintenance personnel. It is not intended to be an operating manual.
- It provides a plant wide common 'look and feel' for the functional description for each plant area control system.
- It incorporates the specific implementation features of the installed equipment.
- It captures the requirements of this document.
- The document shall be adequate detail to program, configure, test and fault find the PLC software.

The document is a specification derived from the PCN by the Control Systems Engineer which clearly defines the functionality to be translated into the PLC and associated control system equipment.

8.4.9.3 As Built

The Contractor shall write the document with "As Built" terminologies. Future tense of wording and references will not be accepted.

8.4.9.4 Logos

The document shall only contain QUU logos, icons, headers footer and borders. The Contractor shall not imbed their company logo onto the document. The Contractor shall state their full name and company details within the revision control table of the document.

8.4.9.5 File Format

The Contractor shall provide the Microsoft Word version of the file to QUU on handover. Where applicable the Contractor shall include all proposed amendments to be provided by others at post-handover eg. proposed future change to PID tuning parameters.

8.4.9.6 Section Numbering

The sections in the document shall be clearly numbered and contain logically defined sub-sections, headings and numbering such that all functionality shall be easily and unambiguously referenced by the prescribed ITPs.

8.4.9.7 Calculations

All single instance calculations shall be clearly outlined in the document. 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 Functional Specification. The Functional Specification should suffix as the reference point for calculations used. Process calculations shall be included within the PCN required.

All lookup tables used within the PLC/RTU or used by a calculation shall be listed in the document. The source of information and revision of the table shall be clearly referenced in the document.

8.4.9.8 Alarming

The Functional Specification shall list all "derived" alarms and all the conditions required to trigger the alarm.

All alarms shall be listed and included with alarm category, masking conditions and latched or self-resetting.

8.4.9.9 Control Loop Diagrams

Refer Appendix G - Control Loop Diagram for a typical loop diagram.

All cascading or complex PID control loops shall be graphically represented using Microsoft Office Visio and inserted into the document. The editable Visio drawing shall be submitted separately with the Functional Specification for future editing requirements.

The control loop diagrams shall display all limits and setpoint clamping, PID manual and auto control signals, sources of setpoints and mode selections. Tagnames and calculations may be included within the blocks where spacing allows.

Small control loop diagrams shall be imbedded into the document whereas larger diagrams shall be attached as an appendix to the Functional Specification.

8.4.9.10 Process Sequencing

The Functional Specification shall detail the requirements for automation sequencing and shall include the following:-

- Provide a high level description of the sequence operation and all clearly defined steps and transitions. A Flowchart shall be used to supplement the description.
- Describe the method used for sequence implementation and all specific function blocks or tools used eg. SFC, FBDs, ladder
- Description of SCADA visualisation and control of sequences – shows all steps, transitions, interlocks, permissives, timers, conditions. The sequence step numbers shall be trended for diagnostics purposes.
- List of operator inputs and action required inclusive of setpoints
- Provide the ability for the operator to 'Pause' a sequence
- Provide the ability for a system to alert the operator that a "manual" operation is required. Once completed, the operator then acknowledges on SCADA, that the manual operation is complete and the sequence is allowed to progress.
- List all Sequence Start permissives
- List all Sequence Run permissives
- Clearly define all step-transition triggers, permissives, actions and confirmation of successful transition for each and every step. For bi-directional sequencing such as blower control, this must include both up and down transitions.
- List all 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 all methods used to detect a sequence failure eg. 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

8.4.10 Software Design Specification

The Software Design Specification is the next level of detail from the Functional Specification 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 an essential document to be able to fault find the RTU/PLC and SCADA systems as well as properly undertake the bench test software simulation, FAT, SAT and commissioning, as well as in reviewing the RTU/PLC code for compliance with QUU standards.

The specification 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 document shall detail the RTU/PLC code configuration and demonstrate how software is structured and in compliance with QUU standards. Selected code backup examples may be provided by QUU for consistency between sites. The Contractor shall follow the site specific structure for brown field sites. Request for deviations or functional improvements may be made through the RFI process.

For small projects the Software Design Specification can be combined into the same document as the Functional Specification. The documents shall be provided in separate documents unless specified otherwise in the Project Documentation.

8.4.11 Software Test Strategy

A Software Test Strategy shall be provided by the Contractor 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 – eg. 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 and operational requirements, validating solution performance against the process control narrative and functional specification

8.4.12 Cause and Effects Charts

The Project Documentation may call for the Contractor to develop Cause and Effect Charts which are complimentary to the control system Functional Specification document and concisely document the operation and interlocks of the process control system.

8.4.13 HMI User Manuals

The Contractor shall prepare separate HMI User Manual for all SCADA Client Workstations and local HMI terminals installed in process areas or switchrooms. The document includes a screen print of each HMI screen and all popup windows and provides a detailed description of all control and monitoring features at each. The detailed document covers all user interface facilities, screen navigation, login privileges, alarm management, reporting, trends, sequences, user setpoint windows, custom devices popups and site specific features.

The documents shall be used by the Contractor to undertake testing of the HMI screens. QUU will not witness any 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 Functional Specification. The documents shall be provided in separate documents unless specified otherwise in the Project Documentation. For STPs there shall be separate site specific SCADA User Manual (i.e. Citect, Mosaic, ClearSCADA, SCADA-C or Radtel) and a local HMI (Redlion) User Manual.

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

8.4.14 PLC and SCADA Function Block Library Specification

The Contractor shall provide a separate document or make additions to existing QUU documents detailing all new function blocks created by the Contractor. As a minimum, the documentation shall contain the full functional specification for the block including but not limited to;

- Full revision control including full name of the programmer, company, date, revision with comments
- Minimum system requirements including;
  - Other dependencies such as other function blocks, subroutines
  - PLC platform including programming software version, patches, service packs,
  - minimum CPU firmware version
- The functionality and purpose of the function block
  - All modes of operation

  - All function block interfaces and data structures shall be itemised and described in detail, including;
  - Fully itemise and describe each row of the data structures (including spares)
  - Each Pin's operation and purpose
  - Register address
  - All tagname suffix eg. aiVolts, aiFlow, diFault
  - Descriptions
  - Data types and length
  - Initial values
  - Engineering Units
  - Scaling parameters
  - Retentive or non-retentive
  - Filtered or non-filtered
  - Pin naming conventions shall given a meaningful description as well detail its usage eg. setpoints, alarm, status, interlock, permissive, operator command, output.
  - 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
  - Analogue limits
- The Pin is defined as the input and output connection points of the function block
- All internal calculations, derived alarms, latched signals, sequencing, statistics etc contained inside the function block shall be detailed in the document. The detail shall be sufficient whereby implementation of the block can 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.

8.5 TEST AND COMMISSIONING DOCUMENTATION

8.5.1 Control System Changeover Plan

For replacement or modification to existing control systems the Contractor shall prepare a detailed cutover and flow control plan that details the activities and sequencing of the cutover and commissioning stages. The plan shall demonstrate that all factors have been considered to ensure minimal and shortest disruption to the operation of the facility. The plan shall nominate what contingency and controls are in place to eliminate hazards and reduce the risk of process upset or environment incidents. The cutover plan shall detail :

- Maximum time that any process or monitoring device may be out of service;
- Transition from existing RTU/PLC control to new, including allowance for field measurement and control while neither are operative;
- Transition from existing SCADA system to new, including operating procedures while both systems are in use.
- Rollback strategy in the event of a failure.

The plan requires collaboration with various QUU stakeholders to understand the operating requirements of the facility. The Contractor shall engage early in the project with QUU stakeholders to determine all control system operational modes, hazards, risks and required risk control measures and any other constraints for STP control systems. The information collected shall be included in the control system changeover plan.

The plan shall endeavour to meet all requirements and constraints advised by QUU stakeholders, so the cut-over of new equipment and control systems modifications can proceed with minimal interruption to operations of the existing facility. The Contractor shall develop the most cost effective and practical cut-over plan and seek QUU acceptance before the planned works is commenced.

8.5.2 Equipment FAT Plan and Report

The Contractor shall prepare separate documents for the Equipment FAT Plan and Equipment FAT Report for electrical equipment and test all control system interfaces with the equipment. The Contractor's plan must demonstrate compliance with relevant standards and QUU standards.

Refer to the following for specific Equipment FAT Plan requirements:-

- TMS60 LV Switchboards and Enclosures - Technical Specifications
- TMS1222 Control Panels - Technical Specifications
- TMS1185 Distribution Transformers(Less than 5MVA) Technical Specification
- TMS1186 HV Switchboards - Technical Specifications
- TMS1187 AC UPS - Technical Specifications
- TMS1188 Transportable Switchroom Technical Specification
- TMS1221 DC Power Supply Systems - Technical Specifications
- TMS1406 LV VSD Technical Specification
- TMS1589 LV Diesel Generators Technical Specification
- TMS1625 Dry Type Transformers(less than 3MVA) Technical Specification

The Contractor shall provide the Equipment FAT Report within 5 business days of the test completion.

8.5.3 Equipment SAT Plan and Report

The Contractor shall provide separate documents for Equipment SAT Plan and Equipment SAT Report for all equipment and test all control system interfaces with the equipment. The Contractor's plan must demonstrate compliance with relevant standards and the following QUU standards.

- TMS1200 Electrical Installation Technical Specification
- TMS1201 Instrumentation Installation Technical Specification
- TMS1595 Cathodic Protection Pipelines and Steel Structures - Standard Technical Specification

The Contractor shall provide the Equipment SAT Report within five (5) business days of the test completion.

8.5.4 Software Simulation Test Plan and Report

The Contractor shall provide separate documents for the Software Simulation Test Plan and Software Simulation Test Report. Refer to section 7.4 for details of the plan contents. The Test Report shall be provided within five business days of the test completion.

8.5.5 Control System FAT Plan and Report

The Contractor shall provide separate documents for the Control System FAT Plan and Control System FAT Report. Refer to section 7.5 for details of the plan contents. The Test Report shall be provided within five business days of the test completion.

8.5.6 Control System SAT Plan and Report

The Contractor shall provide separate documents for the Control System SAT Plan and Control System SAT Report. Refer to section 7.6 for details of the plan contents. The Test Report shall be provided within five business days of the test completion.

8.5.7 Site Commissioning Plan and Report

The Contractor shall prepare a Site Commissioning Plan and a separate document for the Site Commissioning Report. Where applicable the control system commissioning tasks shall be integrated with overall site commissioning plan. The Contractor shall not commence any commissioning activities until the Commissioning Plan has been accepted by QUU. Refer to section 7.7 for details of the Commissioning Plan contents.

The Commissioning Report shall be provided within five business days of the commissioning completion date.

8.5.8 Proof of Performance Test Plan and Report

The Contractor shall provide the Proof of Performance #1 and #2 Test Plans. The plans can be separate document or combined into a common document. At the completion of each phase of the testing the Contractor shall provide a Performance Test Report. Refer to section 7.8 for details of the Performance testing required. The Performance Test Reports shall be submitted for QUU review within five business days of the tests being completed.

8.5.9 Switchboard Changeover Commissioning Plan

Where an existing switchboard and associated control system equipment is being modified or replaced by new equipment the Contractor shall submit an individual switchboard Changeover and Commissioning Plan for QUU review. The QUU acceptance of the Changeover Commissioning Plan is required before site works can commence. The switchboard changeover plan is considered a combined SAT and commissioning plan due to the condensed and short time for the activities allowed.

The Contractor must submit, for each site, a draft version of the switchboard Changeover Commissioning Plan at least ten (10) working days prior to the commencement date for Site Acceptance Testing. TMS78 Sample Typical Changeover Plan informs the Contractor as to

the minimum details for the switchboard changeover plan documentation and other information may be required depending on the specific site conditions and scope of works.

Site telemetry if installed must be maintained at all times when the site is unmanned. An independent battery backed, audible and visual level alarm must be maintained onsite at all times during the switchboard changeover. The switchboard changeover Commissioning Plan must document all stages of the changeover process including use of the temporary power and pumping systems.

Flow control and level alarming during the site installation works shall be the responsibility of the Contractor. As part of the Switchboard Changeover Plan, each site shall have an approved flow strategy which will detail the method to be used for the control of the flow during the switchboard change over.

As a minimum any temporary pumping system will include the provision of a generator complete with at least two (2) pump starter units with automatic level control and an independent battery backed audible and visual level alarm.

Note that flow control must be automatic and not rely on the manual start/stop of pumps.

8.6 OPERATIONS AND MAINTENANCE MANUALS

The Contractor shall provide Operations and Maintenance (O&M) Manuals for all new equipment. This includes;

- two (2) hard copies
- one (1) electronic copy in an editable Microsoft Office format on DVD
- one (1) electronic copy on a QUU Sharefile web-based upload.

The O&M manual must be provides within five (5) business days after the site commissioning is completed.

The Contractor shall provide the O&M manuals in compliance with SEQ Water Supply and Sewerage Design & Construction Code (SEQ WS&S D&C Code).The hard copy manuals shall be neatly presented in 2 ring binders where hole punching is not suitable or the manual is not provided with supports the manual is to be restrained by use of document holder similar to Magi-clip DK3660 with annotated dividers separating the different sections

Loose sheets and drawings not forming part of individually bound booklets within the manual shall be protected in individual plastic pockets. A maximum of two single sided sheets shall be placed back to back in each pocket, allowing them to be read without removal from the pockets.

Each folder shall have the following identifying information on the front cover giving

- Project name,
- Contract number and year of installation,
- Company name, address, email, website & phone number,
- Vendor and sub-contractor specialists name, address, email, website & phone number

Electronic copy of O&M Manual shall be supplied on CD/DVD and be sorted in directories that reflect the layout provided in the hard copy manuals.

All files shall be in one of the following formats to allow QUU to future edit and reprint portions of all of the O&M Manual.

- Microsoft Word (*.doc or *.docx)
- Microsoft Excel (*.xls or *.xlsx)

8.6.1 Generic Manuals

Vendor generic manuals shall be modified with strike thru text or highlighted text by the Contractor to indicate the actual equipment supplied and information contained in the manual must be specific to the equipment supplied.

All generic vendor files shall be in one of the following formats to allow QUU to future edit and reprint portions of the manual.

- Adobe Acrobat (*.pdf)
- Microsoft Word (*.doc or *.docx)
- Microsoft Excel (*.xls or *.xlsx)

8.6.2 Control System Administration Manual

A Control Systems Administration Manual shall be provided by the Contractor. This document shall include detailed technical description of all the Control System components and their communications architecture including all network switch settings.

The Control Systems Administration Manual provides details of all aspects of the As Built control system. The document helps facilitate QUU personnel to understand and maintain the control system in an efficient and effective manner.

The document shall be composed using Microsoft supported documents so can be modified in future.

In order achieve the stated objectives, the Control System Administration Manual shall contain as a minimum the following:-

8.6.2.1 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.

8.6.2.2 Overview of the Site Control System

The document overview section describes the site control systems design, including by not limited to 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.

8.6.2.3 Hardware and Software Files Lists

- A list of all the control systems software applications and tools used for the running of the RTU, PLC, Communications and SCADA system (including server, client software, communication drivers, historian or reporting facilitating software), and engineering workstation applications and tools. This shall include license details, support contact details, software versions, patches applied.
- A record of the IT hardware, operating system and other software used to facilitate the control systems software listed in above point (and includes all addition software used by the operators and technical staff on SCADA servers, clients and EWS, i.e. MS office). This shall include hardware warranty details and contact numbers, software revisions, patches and license details.
- The network hardware list is required for each separate control systems network, i.e. a list for plant wide RTU/PLC to SCADA communication network, a list for Profibus instrument network. The list shall contain the device model, firmware version, complete device addressing information, protocols used. (All devices must be listed, including devices that are not addressed or configured, not viewable in engineering tools, i.e. signal repeaters, media converters, etc).
- The RTU/PLC hardware list shall detail each module, including remote I/O, wireless modules, and any modules that are not configured in the engineering software application but required for operation i.e. battery packs.
- The current controlled documents will be issued to the Contractor where available. The Contractor shall confirm availability of the documents prior to Contract award. The Contractor shall update the existing documents or provide new documents where not provide by QUU.

8.6.2.4 Configuration Files

- All configuration files handed over to QUU for all control systems equipment, including but not limited to PLCs, RTUs, network devices (switches, routers, gateways, and converters), instruments, drives and other electronic devices with settings required to be configured.
- The protocol gateway and network device shall be accompanied by a printed listing of data mapping, setup parameters, firmware revisions, programming software (including revision) and instructions. Wiring diagrams shall be supplied for all non-standard interfacing cables.

Soft copies of the configuration files shall be provided.

8.6.2.5 Network

The network utilisation, spare capacity, performance reports and loading calculations of all control systems networks (including additions to brown field sites) shall be provided.

- Profibus networks shall require a ProfiTrace report to be provided. Other instrumentation networks will require protocol specific standard reports to be produced.
- Performance reports of network switches and routers, including but not limited to average and peak bandwidth utilisation, packet errors, diagnostics etc.
- Where the network is designed with redundancy, the reports shall contain results of redundancy tests performed by the Contractor.

8.6.2.6 Inter- PLC Communications

- Detail all the inter-PLC or peer-to-peer communication transfer schemes and methods of communications, including hardware and protocols used.
- List all inter-PLC or peer-to-peer data mapping and the effect to the process of losing each signal. This is to include mappings used in any protocol converters or other network devices.

8.6.2.7 Operational Control for Maintenance Tasks

This section details the process controls required to be undertaken when performing routine control systems maintenance tasks that require the operation of control systems devices to be interrupted, such as stopping a PLC for firmware upgrade or isolating a local network switch for replacement.

This section shall detail the following:-

- All effected equipment
- Required operator and control systems technician actions to control the affected processes adequately while the maintenance is taking place.
- Any special start up or shut down procedure for control system device.
- Effects on the plant-wide system such as peer to peer communications
- Alarm Listings

8.6.2.8 Testing and Maintenance Schedule

- Provides the required maintenance task and frequency of execution for control systems devices. (i.e. CPU batteries replaced every 12 months, battery test etc).

8.6.2.9 Troubleshooting

Provide 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.

8.6.2.10 Training Manual

The engineering control system training notes and manual shall be referenced or included in the document.

8.7 PRACTICAL COMPLETION

Practical completion shall be in accordance with SEQ WS&S D&C Code's '*Asset Information Specification*' and the QUU addendum (refer Appendix Q, Volume 3 – Appendices).

Practical completion shall be dependent on the following items:

- Completion and commissioning of the works;
- Dismantling and removal of any temporary equipment
- Restoration of the site following the successful completion of the works in accordance with this specification
- Provision of operator training;
- Supply of operation and maintenance manuals;
- Supply of As-constructed drawings
- Removal of all obsolete Control Systems equipment and removal of all obsolete code.

8.8 DEFECTS LIABILITY PERIOD

The defect liability period shall be for a period of twelve (12) months commencing from the date of Practical Completion during which time the Contractor shall provide unconditional warranty for the works. The Contractor shall attend to on-site rectification of all defects attributable to the Contractor on the works for the duration of the defects liability period. Access Authorisation by QUU shall be required for the Contractor to gain access to any live control system. Any subsequent defects remediation works shall be performed under the PRO396 Control Systems Change Management Procedure and FOR603 Control System Change Management Form which shall be completed by the Contractor. The control system modifications must be completed under controlled and fully managed conditions. No remedial changes shall occur without approval from QUU. Approval for all non-critical changes shall only be given after the submission and approval of a test plan and further test documents.

Only under critical circumstances shall the Contractor be allowed to rectify a defect without a specific pre-approved plan from QUU. All the updated documentation covering the change shall be submitted to QUU within two (2) days after the change has been made. The updated software files and any wiring changes to control system circuits shall be made available immediately after the change has been made.

While attendance to rectify any defects will normally be scheduled for the next business day, the Contractor shall have skilled staff available on 24/7 basis to attend site to rectify a defect

should QUU deem the fault to be of a critical or emergency nature. Direct contact details shall be provided from the start of the defects liability period or from when the system is deemed to be operatable.

8.9 TRAINING

The Contractor shall provide a comprehensive training course for all control system hardware and software items included in the Contract scope of work unless specified otherwise in the Project Documentation.

The training includes two (2) off training sessions for minimum duration of 8 hours and up to 8 staff per session held on separate days. The training must be tailored to the intended audience and shall be conducted on-site or at an agreed location and tailored for (electricians, operators and control systems engineers).

The training course shall include but 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 and 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 control systems related equipment, the installation locations, methods of connection and practical live demonstration.
- Engineers and technical staff training shall require separate training supplemented by comprehensive training notes.
- Where new proprietary or non-standard equipment has been introduced to QUU, the Contractor shall host a separate vendor specific training course conducted by the Contractor or the equipment vendor. This course shall be onsite and hosted over two sessions over two days.

The Contractor shall provide comprehensive course notes to accompany the training session which will cover each of the topics.

The course notes shall be prepared and submitted to QUU for review no less than 10 working days before the commencement of the first session.

Training sessions must be provided complete with session plans, outcomes summary and be competency based.

8.10 SITE DOCUMENTATION

8.10.1 Site Record Drawings

During the site works the Contractor shall maintain an updated set of site record drawings and make them available for inspection by QUU upon request. The drawings must not be removed from the site at any time without QUU consent.

On completion of the site works, the red-lined amended drawings are referred to as the "site red-line record drawings", and shall be copied, stamped, signed by the Contractor's site representative and dated as well as signed as approved by the nominated Electrical RPEQ and submitted to QUU.

8.10.2 Miscellaneous Documentation

The following documentation shall be maintained up to date by the Contractor during the execution of the works:-

- Quality Assurance records including ITP's and the associated check-sheets and test records for all control system hardware.
- As-built mark-ups of all Project Documentation to reflect the completed installation.
- A record of all QUU approved changes to the Project Documentation.
- A record of all QUU supplied directives or Site Instructions.
- A record of all Contractor submitted Technical Queries and the associated QUU responses.
- A record of all QUU approved design deliverables.

Upon completion of the Contract works the above listed documentation shall be officially submitted by the Contractor to QUU.

8.11 AS BUILT DOCUMENTATION

The Contractor shall maintain a set of master drawings at the construction site. During the installation phase, the master copy shall be marked in red ink with any changes implemented during the construction.

It is the responsibility of the Contractor to:

- Updated the master set of drawings weekly; and
- Store and maintain up to date inspection checksheets and test result records and certificates generated during testing of the installation works.

Test result records, certificates and drawings with the red-line mark-ups shall be kept in a safe place and will form part of the hand over documentation to QUU.

When a site query has been closed out and the change agreed with QUU, the affected drawings and other documents shall be "Red Lined" to show the revised detail.

8.11.1 As Built Drawings

Unless specified otherwise in the Project Documentation the following drawings shall be back drafted to As-Built status as part of the Contractor's scope of work:

- Drawing Schedule
- Process and Instrumentation Diagrams
- Switchroom layouts;
- Equipment location drawings(instruments and electrical equipment)
- General Arrangements for all electrical enclosures(control panels, switchboards and marshalling panels and DB's)
- 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 and Communication Architecture
- Protection Line Diagrams
- All package-plant related "As-Built" documentation inclusive of all "site-specific customisations" for all electrical and loop drawings, I/O lists, termination diagrams,

The Contractor shall mark "As-Built" corrections on construction drawings used for installation "As-Built" shall be clearly and legibly marked up on all drawings and all changes shall be marked up in RED ink, all deletions shall be marked up in cross-hatched BLUE ink.

All drawings shall be stamped, signed and dated by the Contractor.

The latest revised "As Built" marked-up drawings shall be used during all site testing and commissioning checks.

In the event that parts of the installation are not covered by drawings supplied by QUU, the Contractor shall provide RPEQ approved design drawings or sketches for QUU acceptance.

8.11.2 As Built Documents

The following documents related to the control system shall be As-Built as part of the Contractor's scope of work:

- Process Control Narrative
- Functional Specification
- Control System Administration Manual
- HMI User Manuals
- Training Manual and Course Notes
- All package-plant related "As-Built" documentation inclusive of all "site-specific customisations". Documents such as wired and software Application Program

Interfaces, plant process narrative, functional specification, communication requirements, components listing and spares requirements.

8.12 FINAL COMMISSIONING, TESTING AND INSPECTION REPORTS

All 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 scanned 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)
- AS3000 Certificate of Compliance
- 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

8.13 SOFTWARE CONFIGURATION FILES

At completion of the commissioning phase the Contractor shall provide two off copies of the following software configuration files on either CD or DVD and upload the code to a QUU 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
- IED HV protection relay and associated network equipment 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

The control copy of all configuration and programming files must be loaded on the EWS, installed and ready for support purposes at STP's. The latest backup is also to be copied to the QUU Network Access Drive (NAS).

All associated passwords shall be provided to QUU in a written document.

APPENDIX A – CONTROL SYSTEM PROJECT DELIVERY

Activity	Conditions	Notes	QUU References
Contractor submits key control system design documents as per the SDRL	Software code should not be commenced until key control system documents are accepted by QUU	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	SDRL
Order control system hardware and software licences	Hardware should not be ordered until control system key documents are accepted by QUU	Indicate long lead items in delivery program	
Submit Software Simulation Test Plan	QUU will nominate witness points in the Software Simulation Test Plan		
Execute the Software Simulation Test	QUU will not attend to witness any software testing until test plan is accepted		
Submit Control System FAT Plan and other Equipment FAT Plans	QUU will nominate witness points in the FAT Plans		
Execute the Control System FAT and other Electrical Equipment FAT(switchboards etc)	QUU 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 the software testing are accepted as closed by QUU	
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 QUU		
Submit Control System SAT Plan and other Equipment SAT Plans	QUU will nominate witness points in the SAT Plans.	Site specific Access Authorisation must be granted by QUU prior to site attendance. For software modification to existing sites approval of the change by QUU before any modification to installed software at the site can be undertaken.	FOR603 , PRO396
Execute the Control System SAT in conjunction with other Electrical	QUU will not attend to witness any testing until SAT Plans are all	Control System SAT must not commence until control system FAT Report is accepted by QUU and punch	

Activity	Conditions	Notes	QUU References
Equipment SAT(switchboards etc)	accepted	list items discovered during the FAT are accepted as closed by QUU	
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	QUU will be in attendance for all Commissioning activities	Site commissioning shall not commence until all SAT Reports are accepted by QUU and punch list items discovered during the SAT are accepted as closed by QUU.	
Submit Commissioning Report and all other documentation as per the SDRL		Practical completion is when site commissioning is completed and the Commissioning Report is accepted by QUU. This includes the Control Systems Administration Manual.	
Submit Performance Test Plans #1 and #2			
Execute Performance Test #1	Test #1 must not be executed until performance test plan #1 is accepted by QUU and 7 days after commissioning report is accepted by QUU.		
Execute Performance Test #2	Test #2 must not be executed until performance test plan #2 is accepted by QUU and within 12 months after commissioning report is accepted by QUU.		
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 QUU 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 QUU and approved before any modification to installed software at the site can be undertaken.	

Note: QUU requires 10 business days to review each document submitted for review and Contractor's project delivery schedule must allow for this constraint.

APPENDIX B – TYPICAL CITECT SCADA REQUIREMENTS

The typical Citect SCADA requirements within an STP control room shall be based on the following for quantity purposes unless otherwise specified:

Environmental Licance Limit	SCADA Servers	SCADA web-client licenses per server	SCADA Control Room Client	SCADA Field Clients (single screen)
Small regional STP (< 50,000EP)	Two standard	Two (2) per server. Total of eight (4).	One SCADA client with two monitors.	One SCADA workstation (accesses web-client license on server)
Medium sized STP (50,000 to 1,000,000EP)	One standard and one high performance	Four (4) per server. Total of eight (8).	Two (2) SCADA clients with two monitor each.	Three SCADA clients (accessing web-client license on server)
Large STP (>1,000,000EP)	Two high performance	Five (5) per server. Total of ten (10).	Two SCADA clients with fours monitors + 2 TV screen monitors. Purpose built monitor brackets	Five SCADA clients (accessing web-client license on server)

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