ELECTRICAL & INSTRUMENTATION

TMS1732 - GENERAL SPECIFICATION

Revision Table

Rev No.	Date	Document Status	Owner	Reviewed	Approved
0	17/10/2024	Issue for Use	Craig Moir RPEQ 7480	Mylen Manabat	Kate Lanskey

DOCUMENT HISTORY

Doc No.	Title	Revision	Date	Status
TMS1648	Electrical, Instrumentation & Control Design Criteria	2	Jan 2019	Superseded
TMS1187	Uninterruptible Power Supplies	3	July 2017	Superseded
TMS1221	DC Power Supplies	2	June 2017	Superseded
TMS1406	Variable Speed Motors	4	Jan 2016	Superseded
TMS1200	Electrical Installation	3	May 2021	Superseded
TMS1201	Instrumentation Installation	2	Sep 2017	Superseded
TMS1203	Hazardous Area Installation	1	Oct 2015	Superseded

REVISION HISTORY

Rev No.	Date	Revision Details	Author
0	17/10/2024	Issued for Use	Craig Moir

ENDORSEMENT

Committee	Date
Technical Standards Committee	19th December 2023
ESAG	22nd November 2023

Contents

1 SCOPE

This Specification outlines the minimum technical requirements for the Electrical and Instrumentation (E&I) discipline.

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

1. Design Requirements
2. Equipment Selection
3. Auxiliary Systems
4. Installation

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

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D&C Contract	TEM547 unless superseded by an individual contract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

Except where explicitly stated otherwise, the requirements of this Specification shall be the responsibility of the Contractor as defined in Section 1.1 Definitions.

For detailed information regarding the design of control & communications systems, refer to TMS1733 *Control Systems General Specification*. Topics covered by TMS1733 *Control Systems General Specification* include, but are not limited to:

- PLC and control hardware upstream of I/O terminals
- Ethernet cabling and patching
- Fibre optic cabling, splicing and testing
- Telemetry, including wired and radio telemetry
- PLC programming
- SCADA implementation

1.1 Definitions

In this document, the following definitions apply:

Term	Definition
Project Documentation	Documentation that outlines the requirements of Urban Utilities infrastructure being established through a project. This documentation will form part of the agreement between Urban Utilities and the entity responsible for the development of the relevant infrastructure.

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

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

1.2 Applicability

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

The application of this specification by asset type is as follows

- **Reticulation water supply & sewage service network** - SEQ D&C Code is applicable. Where SEQ D&C Code is silent with regards to the requirements for a particular design or construction element then the relevant Sections of this specification shall apply.
- **Trunk water supply & sewage service** - SEQ D&C Code is applicable through trunk main TMS technical specification. Where SEQ D&C Code is silent with regards to the requirements for a particular design or construction element then the relevant Sections of this specification shall apply.
- **Pumpstations** - SEQ D&C Code is applicable. Where SEQ D&C Code is silent with regards to the requirements for a particular design or

construction element then the relevant Sections of this specification shall apply.

- **Other non-reticulation assets, including Treatment & Reservoirs** - this specification is applicable without limitation

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

2 GENERAL

2.1 Standards and Regulations

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

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

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

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

2.1.1 Australian Standards

Standard	Title
AS 1670	Fire Detection, warning, control and intercom systems – All Parts
AS 1680	Interior Lighting - All Parts
AS/NZS 1768	Lightning Protection
AS 2067	Substations and High Voltage installations exceeding 1kV
AS 2700	Colour Standards for General purposes
AS/NZS 3000	Electrical installations (known as the Wiring Rules)
AS/NZS 3010	Electrical Installation – Generator Sets
AS 4024	Safety of Machinery – All Parts
AS 4070	Recommended practices for protection of low voltage electrical installation and equipment in MEN systems from transient overvoltage's

Standard	Title
AS 4761.1	Competencies for working with electrical equipment for hazardous areas (EEHA) – Competency Standards
AS 60038	Standard Voltages
AS/NZS 60079	Explosive Atmospheres – All Parts
AS 60529	Degrees of Protection Provided by Enclosures (IP Code)
AS/NZS 61000	Electromagnetic Compatibility (EMC) – All Parts
AS/NZS 61439	Low-voltage switchgear and control gear assemblies All Parts
AS 61508	Functional safety of electrical/electronic/programmable electronic safety-related systems
AS 62061	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems
AS 62271	High-Voltage Switchgear and Control Gear – All Parts
AS/NZS 1158.3.1	Lighting for roads and public spaces Pedestrian area (Category P) lighting - Performance and design requirements
AS/NZS 3008.1.1	Electrical Installations – Selection of Cables – Cables for Alternating Voltages up to and Including 0.6/1kV – Typical Australian Installation Conditions

2.1.2 International Standards

Standard	Title
IEC 61850	Communications networks and systems for power utility automation – All Parts
ISO 8528	Reciprocating internal combustion engine driven alternating current generating sets – All Parts
IEEE 519	Recommended Practices And Requirements For Harmonic Control In Electrical Power Systems
NFPA 70E	Standard for Electrical Safety in the Workplace

2.1.3 Acts and Regulations

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

- Queensland Electricity Act (1994)
- Queensland Electricity Regulations (2006)
- Queensland Work Health and Safety Act 2011
- Queensland Work Health and Safety Regulations 2011
- Queensland Work Health and Safety Codes of Practice
- Queensland Environmental Protection Act - 1994 and Amendment Act – 1997
- Queensland Electrical Safety Act 2002 and its latest amendments
- Queensland Electrical Safety Regulations 2013
- Queensland Electrical Safety Code of Practice 2021
- Queensland Professional Engineers Act 2002

- Queensland Professional Engineers Regulation 2003
- Queensland Workers' Compensation and Rehabilitation Act 2003 and Amendment Act 2015
- National Construction Code 2016, volumes 1, 2, 3 and The Guide
- Australian Work Health and Safety Act 2011
- Australian Work Health and Safety Regulation 2011
- Australian Work Health and Safety Codes of Practice 2015
- Queensland Electricity Connection and Metering Manual (QECMM) Version 11

The following water industry codes shall be complied with:

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

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

3 DESIGN

3.1 General Design Requirements

3.1.1 Design Personnel

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

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

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

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

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

3.1.1.1 Hazardous Area Design Competency

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

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

3.1.2 Design Goals

Equipment shall be designed to fulfil the following design goals in order of priority:

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

3.1.3 Design Activities

Design includes the following activities:

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

- For Developer Services projects, milestone submissions refer to the Key Milestones document change

3.1.3.1 Temporary Works Design

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

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

3.1.3.2 Construction Design

Construction design comprises any required design detail not captured in "For Construction" Project Documentation or standard drawings. It shall capture the final element of design required to complete the electrical installation and is completed as part of preparation for construction. All such design works shall complement and not contradict or modify the intent of the design as provided in Project Documentation. Exceptions to this Specification shall be handled as per Section 3.1.7 Exceptions.

Construction design documentation shall be approved by an RPEQ and shall be reviewed and accepted by Urban Utilities before commencing installation works associated with the design.

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

3.1.4 Safety in Design

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

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

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

3.1.4.1 Machine Safety

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

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

- Documentation as per AS/NZS 4024.1201 summarising the risk assessment procedure followed, the results achieved, and the safety measures applied
- Declaration of conformity
- Third party certifications
- Test certificates

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

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

3.1.4.2 Safety Instrumented Systems

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

3.1.5 Asset Numbering

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

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

Refer to TMS1647 *Equipment Tag Naming Technical Specification.*

3.1.6 Documentation

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

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

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

3.1.7 Exceptions

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

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

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

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

3.2 Electrical Safety Requirements

3.2.1 Equipment Hazards

Equipment shall be designed and installed to meet the following aims:

- Eliminate hazards to operators and other persons
- Ensure dangerous forces and gases produced by electrical faults are contained or directed away from personnel. Gases arising from short circuit interruption

or quenching shall achieve safe temperatures and pressures before escaping from equipment
- Insulating and di-electric materials used in electrical equipment shall be nontoxic or be non-hazardous environmental contaminants
- Exposure to arc flash hazards, toxic or flammable substances when operating and maintaining equipment shall be reduced so far as is reasonably practicable (SFAIRP)

Refer to WI58 *Arc Flash Hazard Assessment and PPE Selection* and TEM336 *Power Systems Analysis Guidelines* for details and guidance regarding treatment of arc flash risks.

3.2.2 Evacuation

Services required for safe evacuation shall be designed for 90-minute autonomy after loss of both main and emergency generation. Electrical power shall be provided to allow personnel to be mustered and safely evacuated while maintaining contact with external emergency services.

Refer to Section 3.7.3 Emergency Lighting and Section 4.14.4 Emergency Lighting.

Sufficient clearance for access and evacuation must be maintained, even with all equipment doors open. Refer to AS/NZS 3000 and AS 2067 for minimum requirements.

Exits shall be arranged so that the maximum length of the escape route complies with the requirements of Section D of the National Construction Code.

Switchrooms shall have a minimum of two exits.

3.2.3 Access to Electrical Equipment

Switchrooms, electrical equipment and transformer enclosures shall not be accessible to unauthorised persons.

Oil transformers shall be installed outdoors within a fenced area or locked metal enclosure. Small isolation or dry type transformers may be located indoors. Switchrooms shall be lockable and provided with statutory signs in compliance with AS 1319.

3.2.4 Induced Voltage

Design shall mitigate or eliminate the following hazards:

- Malfunction of control systems equipment
- Back feed from instrument transformers
- Open circuiting of current transformers
- Capacitive coupling
- Induction via parallel circuits

3.3 Environment

3.3.1 Energy Efficiency

Wherever practical, designs shall incorporate renewable energy sources and design features that maximise energy efficiency. Energy efficient designs shall consider budget constraints, industry norms and good practice.

3.3.2 Audible Noise

Electrical equipment selection shall consider sound pressure levels. Noise levels shall not exceed those stated in relevant Australian Standards.

Areas requiring specific consideration include:

- Blower Rooms
- Air Compressors
- Diesel Generators
- Switchrooms
- Pump Rooms

The accumulated noise level (all duty equipment operating at rated load) at the location must comply with the occupational health and safety exposure limit $L_{Aeq, 8\text{-}h}$ to not exceed 85 dB(A), determined in accordance with the requirements of AS/NZS 1269.1.

Refer to TMS1639 *General Mechanical Specification* for specific noise requirements relating to LV Motors.

3.3.3 Spills and Emissions

The following measures shall be undertaken to manage the risk of spills and emissions:

- Oil insulated transformers shall be bunded in compliance with AS2067.
- Wet cell batteries shall be housed such that spills are contained without posing a hazard to the environment
- Corrosive, toxic or flammable gases emitted by equipment in normal or abnormal operation shall be vented to areas not occupied by personnel and other equipment.

3.3.4 Pests

Pests normally encountered are rats, mice, birds, termites, insects, spiders, geckos, snakes, bats and burrowing animals. Installations shall be designed to prevent pests from accessing equipment and cabling. If access cannot be completely prevented the equipment and cables must be resistant to attack or degradation from pests.

Bird resistance barriers or made-for-purpose netting shall be installed on eaves, under roofs and around exposed beams where birds might roost.

3.3.5 Flood

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

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

3.4 Electrical Design

3.4.1 Measurement Units

ISO/IEC 80000 (metric SI system) shall be used. All documentation and correspondence shall be in the English language.

3.4.2 Design Life

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

Table 3-1 Design Life

COMPONENT	MINIMUM DESIGN LIFE
Electrical Equipment & Switchgear	25 years
Cabling & Cable Containment Systems	50 years
Underground Earthing Systems	50 years
Batteries	10 years

3.4.3 Local and Environmental Conditions

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

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

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

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

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

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

3.4.4 Operating Parameters

Parameter	Value
System voltage (HV)	11 kV ±10%
System voltage (LV)	400/ 230 V +10, -6%
Frequency	50 Hz ± 2%
System earthing	MEN
Control Power	Regulated 24 VDC
Special purpose power supplies	Regulated 48VDC and 110VDC

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

3.4.5 Weather and Ingress Protection

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

Location	Rating
Indoors	IP42
Outdoors	IP56
Outdoors – Areas exposed to flooding	IP67

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

3.4.6 Power Systems Analysis

PSAs shall be conducted as per TEM336 *PSA Guidelines* for all new sites and projects that require modifications to the existing power system installed at the site.

Calculations and network modelling shall be provided in support of the electrical design. Refer to TEM336 *PSA Guidelines* for detailed calculation requirements and assumptions to be made.

3.4.7 Load List & Equipment Sizing

New and modified existing assets shall have a load list documenting existing and new loads.

Equipment shall be selected and installed to operate at maximum demand in the worst feasible conditions for its installed environment.

Load lists shall base maximum demand on the driven plant operating maximum load. If this is unknown, the full-load equipment rating shall be used. For lumped loads, load factors shall be applied taking into consideration best engineering practice and the type of load.

Maximum Demand Calculations for distribution boards serving locations intended for human occupation (e.g. office buildings, work sheds, warehouses, kitchens and control rooms) shall comply with AS/NZS 3000. Power outlets and internal lighting circuits at unattended sites shall be assessed on a case-by-case basis, considering typical operation and routine maintenance activities.

Equipment ratings shown on design drawings shall reflect minimum equipment nameplate ratings. Selection of equipment shall consider all relevant derating factors, equipment duty, driven loads and environmental conditions.

Electrical Switchboards and Motor Control Centres

Spare load capacity of 20% shall be provided at the electrical switchboards and motor control centres to cater for future expansion.

Feeders and related equipment serving individual loads shall not be sized for future growth. Where feeder circuits supply multiple loads consideration shall be given to accommodate potential load growth, to the extent of capacity of upstream supplies.

In cases where additional (as opposed to larger) equipment is required to provide reserve for future growth, the excess capacity shall not be installed, but the design shall facilitate expansion should greater capacity be required in the future.

Spare space in switchboards for future undefined switchboard equipment shall be based on 20% of the switchboard incomer, feeder and starter modules, the space calculation shall use module height as the unit for determining the number of spare switchboard modules. Spare module space (unequipped) shall use similar module sizes to the utilised modules.

3.4.7.1 Transformers

The rating of all new transformers shall be the nameplate rating at the site's ambient conditions.

For supply arrangements having more than one transformer serving interconnected buses with one transformer out of service, the remaining transformer(s) shall have sufficient installed capacity to serve the total operating load on the buses, including 20% reserve for future load growth, within economic reason.

3.4.8 Redundancy

3.4.8.1 Essential & Non-Essential Load Classification

Electrical loads shall be classified as follows:

- Essential service – where required to meet a legislative requirement or when failing in operations or failing if called upon to operate could impact the ability of the network to meet a legislative or safety requirement.
- Non-Essential service

Essential loads at RRC, major pump stations and reservoir sites shall be connected to a dedicated essential bus section of the main LV switchboard for the site or process area. The essential bus supply shall be capable of connection to a secondary backup supply.

Network assets typically have a single bus arrangement.

3.4.8.2 Generator Backup Supply

A risk assessment with collaboration from Urban Utilities stakeholders shall be undertaken to determine if a permanently installed generator or external mobile generator connection facility is required. Generator design shall comply with TMS1589 LV Diesel Generator Technical Specification. Switchgear installed within generator packages shall meet the requirements of AS/NZS 61439-1.

For RRC, major pump stations and reservoir sites requiring mobile generators, hardstand space shall be reserved for the generator in the plant layout, outside of hazardous zones and within the boundary of the buried earth grid for HV installations. Two accessible earth bonding points in the vicinity of the generator shall be installed - one for connection to the mobile generator and one for connection to diesel refuelling tankers.

3.4.8.3 UPS Supply

An uninterruptable Power Supply (UPS) shall provide the means to sustain loads requiring continuity of service under supply interruption conditions. Refer to Section 4.5 Uninterruptible Power Supplies for detailed requirements.

3.4.9 Fault and Insulation Levels

The design must allow for a 20% future increase in the maximum prospective fault level over the intended design life of the facility. This is to account for future changes in Supply Authority prospective fault levels.

Derivation of short circuit currents shall be generated as a system modelling output in accordance with TEM336 *Power Systems Analysis Guidelines*.

3.4.10 Electrical Protection

Power system protection devices shall be selected to provide safe fast and coordinated operation, providing tripping of the upstream device nearest the point of fault or overload.

A site-specific Protection Philosophy Report shall be generated for new complex assets with HV distribution or LV distribution incorporating multi-bus switchboards. Other LV installations, including Network sites, do not require a Protection Philosophy Report. Protection for these sites shall be documented entirely within the Power Systems Analysis Report(s) as per TEM336 *Power Systems Analysis Guidelines*.

Where a Protection Philosophy Report is available for existing assets, new protection features shall be consistent with its requirements. Addenda or updates to the document shall outline how proposed network changes will integrate with existing protection schemes.

The Protection Philosophy Report shall describe the topology of the HV and LV network as well as protection schemes used for each equipment type. All operating scenarios including emergency generation shall be described and proposed operational limits outlined. The Protection Philosophy is a key document that shall be submitted early in the design phase.

Refer to Urban Utilities for typical Protection Philosophy Reports indicating minimum content and detail requirements.

3.4.10.1 Primary Protection

Protective devices shall provide adequate safeguards against the effects of any fault occurring on the system or component parts.

Where appropriate (e.g. HV distribution switchboards) unit protection schemes shall be utilised.

Multifunction protective relays shall be implemented for HV protection schemes. The relay protection devices shall be such that a clear indication is given of the fault which caused a trip. HV circuit breakers shall not be capable of re-closure without first manually resetting the fault at the appropriate protection relay.

3.4.10.2 Secondary/Back up Protection

Within unit protection schemes, a CB failure protection shall be implemented to trip upstream protective devices via time / current grading in the instance where the CB to clear the fault does not operate as intended. The clearance time of the backup protection shall be within the withstand capability of the installation and as per AS/NZS 2067 Appendix F.

3.4.10.3 Instrument Transformers

Separate CTs shall be used for metering and protection functions.

CT and VT ratings shall take into consideration the future fault levels and capacity of the system, within economic reason.

3.4.10.4 HV Protection Schemes

The following requirements apply:

Application / Scheme	Requirements
Circuit Breaker Fail	Refer to Section 3.4.10.2 Secondary/Back up Protection
Trip Circuit Supervision	Standalone TCS relays preferred to TCS incorporated into IEDs
CB Lock-out	Shall be provided to main incomers and feeder CBs

Application / Scheme	Requirements
Thermal Overload	Shall be provided for HV cables Both incomer and feeder CBs shall be tripped
Negative Sequence	Provide trip signal to site main incomers
Bus Zone Protection	Shall be provided for HV switchboards Use IEC61850 GOOSE messaging between incomer & feeder IEDs Bus bar blocking shall be used for faults external to the bus zone
Under / Over Voltage	Alarm only shall be provided for main incomers to local HMI & SCADA
Transformer Feeder 2nd Harmonic Blocking	Allows discrimination between faults and transformer inrush currents due to the higher harmonic content of the latter Shall be applied to Phase Over Current & Earth Fault protection

Minimum requirements for HV switchboard and RMU incomer and feeder protection are listed below:

Equipment	HV Switchboard	RMU
Single Incomer	3 phase OC and EF	3 phase OC, OL and EF
Two Incomers and Bus coupler	3 phase OC, EF & directional OC. bus differential	N/A
Feeder	3 phase OC, EF & SEF (configure as alarm and trip) where CB installed	3 phase OC, EF & SEF (configure as alarm and trip where CB installed
Transformer Feeder (less than 1MVA)	3 phase OC, EF & SEF (configure as alarm and trip) where CB installed	3 phase OC, EF & SEF (configure as alarm and trip) where CB installed
Transformer Feeder (greater than and equal 1MVA)	3 phase OC, EF & SEF (configure as alarm and trip), REF (secondary side)	3 phase OC, EF & SEF (configure as alarm and trip), REF (secondary side)
Transformer Feeder (greater than 2.5 MVA)	3 phase OC, EF plus differential protection and thermal protection	3 phase OC, EF plus differential protection and thermal protection
TCS	Required	Required
CBF	Required and utilise IEC 61850	Required and utilise IEC 61850 where CB installed
Blocking Schemes	Required and utilise IEC 61850	Required and utilise IEC 61850 where CB installed

3.4.10.5 LV Protection Schemes

The following requirements apply:

Application / Scheme	Requirements
LV motors	Refer to Section 4.4 LV Motors Refer to typical schematic diagrams
DOL motor starters	Refer to Section 3.5.2 DOL Motor Starters
VSDs	Refer to Section 4.3.18 Protection
LV main incomers & feeders	Refer to TMS60 *Low Voltage Switchboards*
LV Generators	Refer to Section 4.10 Diesel Generators Refer to TMS1589 *Low Voltage Diesel Powered Generators* and TMS60 *LV Switchboards*

3.4.10.5.1 HV Equipment Requirements

The following requirements apply:

Application / Scheme	Requirements
Transformers	• Refer to TMS1185 *Distribution Transformers (less than 5MVA)* and TMS1625 *Dry Type Distribution Transformers* • HV Feeder CBs shall be installed where the transformer nameplate rating exceeds 500kVA
HV Motors	• Refer to TMS1404 *HV Motors* • DOL HV motor starters shall not be used
HV Generators	• HV generators are not preferred. Where required, their protection schemes shall be as per the manufacturer's standard offering. Generator protection schemes shall be co-ordinated with the site protection schemes and suitable for the site earth grid.
HV Switchboards	Refer to TMS1186 *HV Switchboards*

3.4.11 Metering

3.4.11.1 Check Metering

Check metering data for HV switchboards shall be accessed from the IEDs and displayed at the local HMI and site SCADA. Refer to TMS1186 *HV Switchboards* for data to be accessed.

Check meters shall be provided in a metering section of main LV switchboards. Check meters shall be provided in other LV switchboards exceeding 250A rating. Meters shall be selected from TMS62 *Preferred Electrical and Instrumentation Equipment List*. Metering data shall be displayed and trended at the RRC site SCADA.

3.4.11.2 Revenue Metering

Supply Authority (Energex) owned revenue meters and instrument transformers shall be installed in a standalone panel in accordance with the Supply Authority standard design.

Revenue meters for new outdoor LV switchboards at Network Asset sites shall be integrated into the switchboard in accordance with the Supply Authority's requirements and Urban Utilities standard design drawings. Where the switchboard is installed indoors a standalone metering panel shall be installed external to the switchroom building in a readily accessible location to the Supply Authority.

Revenue metering sections of a new switchboards require upstream isolators that can padlocked in the "isolated/off" position.

3.4.12 Interlocking

An Interlocking Specification shall be developed for new LV switchboards with multiple incomers, ATS or MTS as well as HV switchboards and RMUs. The document shall describe the following in detail:

- Mechanical interlocks between protective devices, isolators and doors
- Hardwired electrical interlocks
- Control System software interlocks programmed in IED devices
- Step by step instructions for safely isolating/de-isolating equipment under all operational scenarios
- Interlocking drawings showing hardwired and key interlocks superimposed on the switchboard SLD

The following requirements apply to interlocks:

- Interlock key systems shall be simple (i.e. shall not require lock boxes or complex sequencing)
    - The preferred key type for new switchboards and RMUs is RONIS
- Mechanical, electrical and control system interlocks shall operate to reinforce each other
    - Hard-wired electrical and mechanical interlocks shall be detected and monitored where possible in the IED devices
    - The PLC alone shall not be used to implement interlocks that can impact safety of persons
- For new HV installations, safety and operational interlocks shall not solely rely on administration procedures
- Interlocks between upstream and downstream devices shall be provided
    - This shall also apply to interlocks between LV and HV devices
- Interlocks to existing upstream or downstream equipment shall be provided

Adequate provision shall be made in the design for potential future expansion of the site.

3.4.13 Power Network Topology

The structure of the electrical distribution system is generally based on the following criteria:

1. The rating of system components shall be based on maximum demand in accordance with AS/NZS 3000 and the allocation of this equipment to the production areas at the site.
2. For complex sites the main LV switchboard supply redundancy shall be provided by means of multiple feeders and associated bus ties.
    a. Bus bar configuration shall allow one bus section to be taken out of service while still maintaining a minimum level of plant operations.
    b. In normal operation, the bus tie circuit breakers shall be open to minimise fault currents on the bus bar.
    c. Where there are bus ties, switchboard bus sections are to be physically separated to enable each section to be maintained independently.
3. The equipment shall be rated for the maximum short-circuit current that may occur in the respective section of the supply system.
4. Parallel operation of incomers shall be prevented by means of mechanical and electrical hardwired interlocking.
    a. If parallel operation can occur, downstream equipment shall be adequately rated. This is applicable for short duration switching operations where switchboards are fed from multiple transformers simultaneously.
    b. Refer to Section 3.4.12 Interlocking.
5. Sites shall be supplied from utility (grid) connection.
6. Sites requiring backup generator supply (permanent or mobile) shall comply with the following:
    a. Generator connections shall be via ATS for permanently installed generators and MTS for mobile generators.
    b. Transfer switches shall be internal to the switchboard .
    c. MEN connections shall reside in the LV switchboard. A warning label shall be provided at the switchboard connection point to disconnect the MEN from the mobile generator.
    d. Refer to Section 4.10 Diesel Generators for detailed requirements.

3.4.14 Power Factor Correction

The formal Connection and Access Agreement with the Supply Authority (Energex) imposes power factor (PF) limitations at the point of supply. For modifications to existing operational sites the PF range shall be assessed. The design shall ensure the PF at the point of supply is within these limits.

If a PFC unit is required, it shall be installed in an air conditioned switchroom. PFC units shall provide both local and remote control / monitoring. The PFC unit controller shall be integrated into the site protection philosophy and site control system.

3.4.15 Harmonic Distortion

The specification of harmonic distortion producing equipment such as rectifiers, inverters, variable speed drives, power factor correction equipment, etc. shall give due consideration to the level of harmonic voltage and current distortion caused by the equipment.

The total harmonic voltage and current distortion at the point of supply shall be within values specified in TEM336 *Power Systems Analysis Guidelines*.

Harmonic mitigation techniques shall be in the following order of preference:

- Specification of equipment which generates low levels of harmonic voltage and current distortion, or has integral harmonic filtering equipment
- Provision of standalone harmonic filtering equipment including passive and active harmonic filters

3.4.16 Electromagnetic Compatibility

Measures shall be taken to reduce the probability of low frequency induction and radio frequency interference (RFI) regarding:

- Equipment specification
- Equipment location
- Cable installation segregation
- Earthing and bonding

RFI shall be limited such that it does not interrupt normal operation of the process or process related equipment, including controllers, instrumentation and telecommunications. RFI shall be as specified in AS 61000 series on electromagnetic compatibility (EMC).

3.4.17 Earthing Systems

3.4.17.1 General

Earth grids for sites containing HV supply shall be designed strictly in accordance with AS 2067. HV and LV earth grids for new sites shall be combined. Where an existing site has segregated LV and HV earth grids, any design modifications to the earth grids shall combine the grids together via permanent continuous bonding.

The earth grid design shall allow for 20% increase in prospective fault level in the Supply Authority HV network over its intended design life. The fault clearing time to be assumed for the basis of the earth grid design is the protection maximum back-up clearance time and shall not be less than 0.5s, unless accepted otherwise in writing by Urban Utilities.

Earth grids installed in highly corrosive environments (e.g. acidic soils) shall incorporate mitigation measures including use of stainless steel grade 316 earth rods.

Refer to Section 5.7 Protective Earthing and Lightning Protection for installation and testing requirements.

Refer to TEM336 *Power Systems Analysis Guidelines* for other design specifications and deliverables required for earth system design.

3.4.17.2 LV Earthing

If required, earth grids for LV switchrooms shall consist of a minimum 120mm^2 bare annealed copper conductor routed underground around the switchroom perimeter and minimum 600mm^2 depth of soil cover. As a minimum the electrodes shall be located near the corners of the building and bonded to the underground earth conductor in an electrode pit. A minimum of two 120mm^2 PVC earth cable connections shall be run from the internal wall mounted LV switchroom earth bar to the underground earth grid.

A direct earthing system shall be used for LV distribution.

For existing sites the MEN connection may be at the transformer earth bar. For new installations or works where the transformer or main LV switchboard are replaced, then the MEN connection shall be in the main LV switchboard at the main earth bar (MEB). An earth bar shall be provided for each switchroom and shall be utilised for the equipotential bonding of equipment within the switchroom. Each switchboard within the switchroom shall be equipped with an integral earth bar that shall be bonded to the switchroom earth bar.

At locations with a high density of electrical equipment (e.g. equipment skids), dedicated field earth bars shall be provided for earthing equipment within the area.

The earth system for single-switchboard Network assets shall, at a minimum, include an earth pit containing an electrode bonded to the main earth bar in the switchboard.

3.4.17.3 HV Earthing

HV substation earth grids shall comply with AS 2067 and consist of an array of electrodes (maximum spacing 20m) interconnected with bare copper conductors. The grid spacing shall not be larger than 5m squares where practical to install.

Where there are multiple HV substations located on a site, all HV earth bars shall be interconnected by a minimum of two 120mm^2 PVC earth cables.

For substations containing LV and HV switchrooms there shall be separate LV and HV switchroom earth bars provided. A minimum of two 120mm^2 PVC earth cable connections shall be run from HV switchroom earth bar to the new underground earth grid.

An earth bar shall be provided for equipment such as RMUs, transformer compounds etc. and shall be utilised for the equipotential bonding of equipment within the transformer compound. Local earth grids at equipment such as RMUs, transformer compounds etc. shall be bonded to the main substation earth grid by a minimum of two 120mm^2 earth PVC cables. Switchroom and transformer earth bars shall be bonded to the facility MEB via PVC insulated earth cables.

3.4.17.4 Existing Earth Systems

The physical condition and extent of the earth system components installed for existing assets cannot always be easily verified and the as-built- design documentation is not always available or accurate. The design for new earth grids at existing sites shall not rely on or make assumptions for the performance of any existing earth grid members in near vicinity of the proposed new earth grid. For modifications to earth grids at existing facilitates, the building foundations and all other underground structures in the vicinity of the proposed new earth grid shall NOT be considered when designing and modelling the performance of the new earth grid.

Design drawings shall show bonds to existing structures and existing earth grid members where these can be verified at the site and are in adequate physical condition for continued service. Verified layouts of these existing components shall be shown on the design drawings. Design drawings shall mark out for decommissioning and removal any existing earth system members made redundant by the design. The design shall ensure new earth grids bond to the existing earthing system at two points at minimum.

3.4.17.5 Transfer Potentials

Earthing design shall consider the risk of transfer of potential rise due to earth faults as per TEM336 Power Systems Analysis Guidelines and current applicable standards including but not limited to AS/NZS 3000 and AS/NZS 2067.

The earthing design shall consider structures with the potential to transfer potentials. These typically include but are not limited to:

- Metal fencing
- Piping
- Cable sheathing
- Cable ladder
- Earth and equipotential bonding

The design shall consider insulated sections at the boundary or earthing method for metal pipes, fences and cable ladders that cross a substation boundary to prevent transferred potential to other parts of the electrical installation and other impacted parties.

3.4.17.6 Equipotential Bonding

Refer to Section 5.7.2 Equipotential Earthing for detailed installation requirements.

Sites requiring two or more area earth bars (including the MEB) shall have an equipotential earthing loop installed throughout the plant area. This earthing loop shall be used for equipotential bonding of the equipment and structure throughout the plant and conform to the following minimum requirements:

- A PVC earth cable shall be used
- Cable shall start and finish at the MEB
- Cable shall be run throughout the plant on the power cable ladder system
- Sizing basis:
    - Sites with LV supply, 25mm^2 (minimum) to 120mm^2
    - Sites with HV supply, 35mm^2 (minimum) to 120mm^2
    - Sized such that cable could be relied upon on to keep touch potentials in the cable ladder system below unsafe levels without reference to any other paths to earth (including individual circuit earth conductors or the continuity of the cable ladder system itself)

Non-current carrying metallic parts and enclosures of electrical equipment and metallic structures used for mounting electrical equipment shall be effectively bonded to the earth grid throughout the site so as to ensure that exposed conductive parts are at equal potential during normal operation and under fault conditions. Standard earthing installation drawings for the types of equipment to be installed shall be provided.

To bridge the insulating effect of the anti-vibration mountings on mechanical packages, bonding conductors shall be used to connect the otherwise insulated equipment to the equipotential earthing loop or for existing sites without an equipotential earthing loop to the adjacent structural steel.

3.4.17.7 Low Frequency Induction

Pipelines in the vicinity of HV transmission lines may be exposed to Low Frequency Induction (LFI). Where proposed pipelines run parallel to nearby HV transmission lines, CDEGS modelling software shall be used to determine LFI voltage levels and an LFI design report shall be provided. LFI voltages imposed on equipment must be considered for both steady state and fault conditions in the HV lines.

3.4.17.8 Instrument Earthing

Instrument earth design shall be in accordance with the requirements of AS/NZS 3000 and Section 5.7 Protective Earthing and Lightning Protection. Earthing in intrinsically safe systems shall conform to AS/NZS 60079.11.

Instrument earthing systems shall achieve the following:

- Protect instrumentation and control systems from electromagnetic interference (EMI)
- Prevent generation or propagation of EMI by the instrument earthing system itself
- Provide a 'clean' earth separate to the main earthing system
    - The main earth system shall be used for safety earthing only

Instrument earthing systems shall fulfil the following requirements:

- Each site shall have a main instrument earth bar
- Local instrument earth bars shall be located at local control panels, marshalling panels or the PLC sections of area MCCs and shall connect to the main instrument earth bar via PVC earth cables
- The instrument earth system shall connect to the main earth system at a single point only (typically a bond between the main instrument earth bar and the MEB) but shall otherwise be electrically segregated from the main earth system
- The instrument earthing system shall be used for all non-IS screening applications and 0V signal references.

Instrumentation and control cables shall be shielded from EMI by means of cable screens earthed at one end only. This provides a path to earth for EMI-induced currents and averts the production of EMI via currents circulating within loops in the earthing system. The following requirements apply:

- Each pair / triad / quad shall be individually screened
- Multi-pair / triad /quad cables shall have an overall screen
- Screens shall terminate at the instrument earth bar only
- Screens shall, across their whole length, be electrically segregated from:
    - Each other, except when terminating at the instrument earth bar
    - Instrument housings, junction box housings, signal conductors, metallic cable armour or any other conductive parts that may be connected to the main earth system
- Screens shall maintain continuity:
    - Between the end terminal at the final device and the instrument earth bar
    - Through intermediate junction boxes by means of through-terminals
    - As far as possible up to the end termination (i.e. screens shall not be cut off at the gland)
- Cable armour shall not be used as a substitute for cable shields

Instrument loop surge protection devices shall be connected to the control panel instrument earth bar as per the manufacturer's recommendations.

The following items related to instrumentation shall be connected to the main earth system and not the instrument earth system:

- Field instrument housings

- Junction box housings
- Control system enclosures
- Cable armour (via the glands at both ends and at intermediate junction boxes). Where earths are to be terminated in a junction box, earth terminals shall be provided

3.4.17.9 Static Electricity in Hazardous Areas

Static electricity in hazardous areas shall be controlled in accordance with the requirements of AS 1020 by the provision of secondary earthing supplemented by the provisions of this section.

Particular attention shall be given to the provision of adequate paths to earth preventing the build-up of potentially hazardous static charge levels arising from the flow of gas and fluids under both normal and abnormal operating conditions.

All parts of metallic piping systems crossing hazardous areas shall be earthed with a resistance to ground not exceeding 10Ω regardless of whether the fluid being transported is conductive or not. Bonding is not required across joints in the metallic piping system, except for flexible, swivel or sliding joints. If the resistance across pipe connections is greater than 1MΩ, the pipes on either side of the connection shall be bonded together by a suitable conductor and earthed.

Electrically isolated parts of metallic piping and components shall be bonded to the remainder of the piping system and earthed.

Electrostatic earthing shall not compromise sections of pipe that are to be electrically isolated (e.g. insulating flanges on cathodic protection systems).

3.4.17.10 Earth System Design Documentation

The following is a list of the minimum design deliverables required for an earth system design:

- Earth Grid Design Report as per the requirements of TEM336 *Power Systems Analysis Guidelines*.
- Earth Grid Layout Drawings showing locations of earth bars, above and below ground earth conductors, earth tails to equipment and structures, joints, electrodes and the MEN link
- Earth bar general arrangement drawings showing size, conductor connections, tag names and mounting details.
- Installation detail drawings for new electrodes and earth connection types

3.4.18 Modifications to existing low voltage switchboards

The following requirements shall be complied with where an existing low voltage switchgear assembly is modified, modifications include: extension of the assembly, replacement of circuit protective devices which are not like for like, modification to the

power circuit of a functional unit, modification to the assembly enclosure which may impact temperature rise performance, modifications to the assembly busbars or supports.

3.4.18.1 Verification of Fitness for Service

The switchboard modifications shall be verified to meet the requirements of AS/NZS 61439-1, this should be undertaken by the original switchboard assembly manufacturer if still trading, this does not require re-verification of the complete assembly unless the modifications would require alterations to busbars or other major structural component parts of the switchboard which could impact the fundamental safety features of the switchboard.

Should the original assembly manufacturer not be available to perform the verification, then the modifications should be assessed by a competent manufacturer. This should include the existing assembly and the acceptability or otherwise of the proposed modifications.

The design verification shall be performed by an engineer experienced in the application, design, manufacture, testing and verification of switchboards to AS 3439 and AS/NZS 61439.

The manufacturer shall provide a statement describing the fitness for purpose of the assembly taking the modifications into account. Any limitations in future operation of this equipment should be detailed in the fitness for service assessment. The fitness for service assessment shall be submitted for acceptance by UU.

In line with industry guidance available, only replacement devices of the same type should be used, i.e. MCCB for MCCB, similar performance characteristics, the substitution should follow the requirements for substitution as stipulated in AS/NZS61439.1 clause 10.10.3.5. If temperature rise verification is being undertaken by assessment, then the limitations of AS 60890 shall be adhered to.

3.5 Switchboard Control System Design

This section is intended to complement information contained in TMS1733 *Control Systems General Specification* and TMS60 *LV Switchboards*. The information provides further clarity for the control system design associated with electrical switchboards and motors.

3.5.1 Switchboard Control System Applications

3.5.1.1 LV Switchboards for RRCs

PLCs shall not be integrated into the same enclosure as the LV switchboard at RRC sites.

For outdoor switchboards, motor local control and monitoring shall be provided using start/stop pushbuttons, switches, HMIs or keypads on motor starter compartment escutcheons.

Control panels associated with LV Switchboards at RRC sites shall incorporate a HMI for remote control and monitoring of switchgear items (Refer to TMS62 *Preferred Equipment List Electrical and Instrumentation*), where control and monitoring is provided by push-buttons and indication lamps these shall be mounted in . Local HMI terminals shall not be mounted directly on enclosures exceeding Arc Flash PPE Category 0. The control and monitoring features of the local HMI shall be replicated at SCADA.

DOL motor starters shall be provided with MPUs (Refer to TMS62 *Preferred Equipment List Electrical and Instrumentation*). MPUs shall communicate with the local PLC over a standard industrial network protocol in a star network topology. Motor starter control and status data shall be displayed at the local HMI and site SCADA. The design intent is to minimise control wiring between the switchboard and the local PLC and to streamline FAT of the control system.

Remote I/O modules shall be provided in the switchboard for I/O signals not related to DOL motor starters and these would normally be in a separate compartment of the switchboard.

Except where accepted in writing by Urban Utilities, all motor process control functions shall reside in the PLC. No process control logic may reside in MPUs or other programmable devices. Exceptions may be considered for Packaged Plant equipment supplied with proprietary control systems or where significant functional, cost or reliability gains may be realised.

3.5.1.2 LV Switchboards for Network Assets

The control system for new LV switchboards at Network Assets shall be as per Urban Utilities standard design drawings.

Standard designs are suitable for switchboards requiring Arc Flash Category 0 PPE. For new switchboards exceeding Arc Flash Category 0 PPE, control system components shall be in a separate standalone Control Panel. The control panel shall be manufactured to TMS1733 *Control Systems General Specification*.

3.5.1.3 HV Switchboards

HV switchboard remote control and status monitoring by the site control system shall be implemented.

This includes the following:

- Control panels associated with HV switchboards shall incorporate HMIs for remote control and monitoring of switchgear items
- Monitoring and trending of voltage, current, frequency, power, power factor etc. of incomers and feeders at local HMI and SCADA. Trends only provided at SCADA terminals.
- Monitoring of the status of all devices including CBs, LBSs, and ESWs, IEDs, surge diverters etc at local HMI and SCADA
- Remote Control (Open and Close) of CBs and LBSs at the local HMI only. HMIs shall not allow control of HV equipment located in other plant areas

3.5.2 DOL Motor Starters

Automatic motor control is by sequence logic programmed in the PLC. The Auto/Manual and Remote/Local mode selections shall be performed at the local HMI and at SCADA.

Summary of motor control features as follows:

Control Mode	Control Facilities
Auto	Process control from PLC sequence logic
Remote Manual	Control using motor START/STOP pushbuttons at the local HMI or Motor START/STOP pushbuttons at motor starter escutcheon or Motor START/STOP pushbuttons at SCADA
Local Manual	Control using motor START/STOP pushbuttons at the LCS

When selected in Auto mode, START/STOP pushbuttons for manual control are disabled.

Emergency stop pushbuttons and other safety function devices shall be hardwired to the motor starter and monitored by the local control system for deploy of alarms at the local HMI and SCADA. Refer TMS1651 *Machine Safety Implementation* for implementation of emergency stop circuits.

Refer TMS60 *LV Switchboards* for further design requirements related to control and monitoring of motor starters.

3.5.3 VSD and Soft Starters

The following requirements apply to both VSDs and soft starters:

- VSDs and soft starters shall have similar control features to DOL motors (refer to Section 3.5.2 DOL Motor Starters)
- All process control functions shall reside in the PLC processor. Control logic shall not reside in the VSD or soft starter unless otherwise accepted by Urban Utilities.

- Emergency stop pushbuttons and other safety function devices shall be hardwired to the VSD or soft starter and monitored by the local control system for deploy of alarms at the local HMI and SCADA. Refer to TMS1651 *Machine Safety Implementation* for implementing emergency stop circuits.

The following requirements shall apply specifically to VSDs:

- Manual speed control for VSDs shall be provided at the local HMI or at the VSD starter panel.
- VSDs supplied with Packaged Plant equipment may be located on the skid with the mechanical equipment and provided with a unit control panel. It is however preferable to install VSDs in air conditioned switchrooms.
- Standalone outdoor VSDs shall be IP54 rated within an IP56 outer enclosure.
- Control circuits shall be designed to be "fail safe". Failure of a circuit component(s) shall cause power circuits to open, control circuits to generate stop signals and cause equipment to go to a safe condition.
- Fuses shall not be used in circuits where blown fuses would cause transmission or reception of erroneous signals or reference voltages.
- VSDs shall be supplied with proprietary diagnostic and setting software specific to the VSD.
- Maximum and minimum operating speeds shall be programmable from VSD front panel.
- The acceleration ramp rate from start up to the minimum speed setting shall be programmable. This setting shall not affect the acceleration and deceleration rates within the control speed range at any other time.

Soft starters in RRCs are generally only required on larger motors typically exceeding 30kW.

3.5.4 Emergency Motor Control

Where a motor is considered critical to safety of personnel, plant or is essential for production availability, its MPU display or VSD keypad may have facilities to select LOCAL mode to override any HMI and SCADA mode selection. LOCAL mode may also be selected at the LCS using a hard wired Local/Off/Remote or Local/Remote selector switch to the MPU.

The intention is to allow operation from the field LCS or MPU under emergency conditions (e.g. PLC is out of service and/or local HMI and SCADA is unavailable). Other equivalent design solutions may be proposed for local control under emergency conditions.

3.5.5 LV Switching

LV protective devices and isolators exceeding 400A rating shall be remotely operated using the local HMI or remote push-button station. Local control push-buttons shall be mounted at the switchboard escutcheon. Switchboard mounted controls are intended to be used in an emergency and/or the local HMI or control system is unavailable.

PLC panels incorporating local HMIs for switchboard operation shall be placed outside the switchboard's arc flash boundary. A warning label shall be provided at the switchboard directing operators to use the HMI rather than the switchboard controls.

MCCBs and isolators rated ≤400A do not require motorised control facilities. PPE as specified on the switchboard arc flash label shall be used when performing manual switching tasks at the switchboard.

3.5.6 HV Motor Control

Where the HV motor is part of a large vendor package (e.g. air blowers), control shall be from a unit control panel complying with TMS1645 *Package Plant EI&C Requirements*.

3.5.7 HV Switchboards and Ring Main Units

Refer TMS1186 *HV Switchboard Technical Specification*.

3.5.8 Emergency Stop Circuits

Emergency Stop circuits shall at minimum be Category 2 in accordance with AS/NZS 4024.1501. This may be reduced by risk assessment (see Section 3.1.4.1 Machine Safety). An RPEQ-approved design report shall validate the reduction in Category.

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

3.5.9 Auxiliary Devices

The control system shall supervise and acquire data from auxiliary devices (e.g. UPSs, DC supply systems, battery monitoring systems) and other equipment (e.g. Vibration monitoring systems) directly via Modbus TCP or other accepted protocol. Refer to TMS1733 *Control Systems General Specification*.

3.5.10 Local Control Stations

The following requirements apply:

- Motors shall have a dedicated LCS installed adjacent to the motor
- Emergency Stop pushbutton(s) shall be provided at all motors
- Start/Stop pushbuttons shall be enabled only when Local mode is selected
- The LCS Stop pushbutton may be omitted and replaced by an Emergency Stop pushbutton where accepted by Urban Utilities
- Local manual control facilities for HV and large (>30kW) LV motors shall be risk-assessed and selected during design with input from Urban Utilities operators

- These generally will not have STOP/START pushbutton controls provided at the LCS

Refer to Section 3.1.4.1 Machine Safety and TMS1651 *Machine Safety Implementation.*

Refer to Sections 5.3.11 Local Control Stations for detailed LCS construction requirements.

3.5.11 Functional Specifications

Refer to TMS1733 *Control Systems General Specification* for minimum content and detail to be included in a control system functional specification document.

3.6 Hazardous Areas

3.6.1 General Requirements

Plant areas where formation that explosive atmospheres is likely to occur as part of normal operation shall be classified as Hazardous Areas (HAs) in accordance with AS/NZS 60079.10.1.

Electrical equipment and instrumentation shall be located in the least hazardous zone possible. Switchrooms and instrument air packaged plants shall be located in non-hazardous areas.

Projects with HA scope shall be delivered in compliance with MP183 *HA Management Plan.*

3.6.2 Classification

HA Classifications shall be completed to the latest edition of AS 60079.10.1. Urban Utilities requires HA Classification Reports to be standardised in terms of content and layout and will provide a report template to be used for this purpose. HA Classification Report minimum contents are specified in MP183 *HA Management Plan* and TEM518 *HA Verification Dossier Template*. Existing HA Classification Reports shall be updated to comply with TEM518 where required.

3.6.3 Equipment Ex Certification

All electrical equipment/devices and instrumentation installed in hazardous areas shall:

- Be selected and installed in accordance with AS/NZS 60079.14 and AS/NZS 60079.17
  - Equipment shall carry certification for use in hazardous areas
  - Certification shall be in accordance with the ANZEx, or IECEx certification schemes
- Be installed and used within its electrical ratings
- Consider zone, temperature class, gas group, and ambient temperature

- Be installed to meet the area classification as per the respective hazardous area drawings
- Have ingress protection rating meeting environmental and operational requirements
- Satisfy the fault containment rating of enclosures for electrical equipment and devices
- Be installed to offer easy access for inspection and maintenance

A copy of the Certificate of Conformity for each piece of equipment/device associated with the electrical and instrumentation installation shall be provided in the HA verification dossier. Certificates of Conformity shall also be provided for certified installation components or associated equipment such as intrinsic safety barriers, bungs, adaptors, conduits, and cable glands.

The use of equipment certified to an alternative standard to those stated above shall be restricted to circumstances where suitable equipment with acceptable certification (AusEx, ANZEx, or IECEx), is not obtainable. Justification for the use of such equipment shall be included in the HA verification dossier and shall take the form of a Conformity Assessment Document (CAD) compiled by a competent person. The requirements for issuing Conformity Assessment Documents for alternative certified equipment are those given in AS/NZS 60079.14.

3.6.4 Repaired, Overhauled and Modified HA Equipment

Repaired or overhauled HA equipment shall not be installed unless approved in writing by Urban Utilities.

No unauthorised modifications to certified HA equipment will be accepted.

Modified equipment shall be either re-certified or rejected. The equipment as installed shall be in a condition that meets the content of the original certificate of conformity (applicable for any repair or overhaul works done).

Requirements of AS/NZS 60079.14 regarding the topic of repaired, overhauled and modified equipment shall be strictly followed.

3.6.5 Methods of Protection

The following table shows the preferred method of protection for electrical equipment and devices installed in hazardous and non-hazardous areas:

Application	Zone	Type of Protection
Instrumentation & associated junction boxes	0, 1, 2	Ex ia
Non-I.S. marshalling cabinets & junction boxes	2	Ex e
LCSs and emergency stop buttons	1, 2	Ex de
Motors	2	Ex n

The following table shows the preferred method of protection for all other equipment:

Zone	Type of Protection	Description	Order of Preference
Zone 0	Ex ia	Intrinsic Safety (level 'a')	1
Zone 1	Ex e	Enhanced Safety	1
	Ex d	Flameproof	2
	Ex m	Encapsulation	2
	As per Zone 0		
Zone 2	Ex n	Non-Sparking	1
	Ex p	Pressurised	2
	As per Zone 0 & 1		
Non-Hazardous (NH)	N/A		N/A

3.6.6 Additional Considerations

3.6.6.1 Temperature

Ex equipment shall at minimum be designed for ambient temperatures ranging from -5°C to +45°C.

Equipment temperature class ratings are selected to keep equipment surfaces below the minimum auto-ignition temperature of the gas / dust forming the explosive atmosphere. Considerations made when selecting equipment temperature classes shall include anything that may abnormally increase equipment surface temperature, including ambient temperatures above 40°C, incident sunlight and hot surfaces. Equipment shall be protected from direct sunlight wherever possible.

3.6.6.2 Vibration

Excessive vibration may have deleterious effects on equipment Ex certifications. Where necessary, equipment shall be isolated from sources of vibration. Regular inspections of equipment will be conducted and where loosening of enclosure bolts, terminals, and the like are identified.

3.7 Lighting

3.7.1 General

Lighting shall be designed to relevant Australian standards to enable safe access for operation and maintenance purposes in low natural light conditions.

Energy efficiency, ease of maintenance and reliability of the lighting system components shall be taken into consideration in the design.

Lighting designs shall be in accordance with Section 5.8 Lighting and Small Power.

Lighting lux level plots shall be provided for each site area using AGI32 or similar lighting design software. The luminaire locations shall be superimposed on the site layout drawings and indicate mounting height, angles of inclination and maintenance factors allowed.

3.7.2 Lighting Parameters

Requirements for lighting parameters are generally based on the AS 1158 and AS 1680 series of standards.

Application of the standards shall be as per the table below:

Area	Standard Applied
Outdoor pathways (including covered walkways) and in-plant roads	AS 1158.3.1
Indoor, non-process areas. Includes staff amenities, control rooms, switchrooms, hallways, stairs. Excludes office areas.	AS 1680.2.1
Office areas	AS 1680.2.2
General outdoor process and work areas	AS 1680.5
Indoor work areas and outdoor process areas requiring operator intervention	AS 1680.2.4

General guidance for various applications is provided below:

Application	Standard	Minimum Requirement	Lux Level*
Outdoor pathways outside process areas	AS 1158.3.1	Subcategory PP4	1.5 (ave)
In-plant roads	AS 1158.3.1	Subcategory PR4	1.3 (ave)
General outdoor process areas (little to no operator intervention), includes open and covered walkways/pathways (pedestrian traffic only, no vehicles)	AS 1158.3.1	Subcategory PA3	7 (ave)
General outdoor process areas (little to no operator intervention), includes open and covered walkways/pathways (mixed pedestrian & vehicular traffic)	AS 1158.3.1	Subcategory PA1	21 (ave)
General indoor process areas	AS 1680.2.4	Table E1, Item 10.1 or equivalent	40 (maint.)
Process areas (remote control with sporadic intervention, automated solid material handling, outdoor pumps)	AS 1680.2.4	Table E1, Item 9.1 or equivalent	80 (maint.)

Application	Standard	Minimum Requirement	Lux Level*
Storage sheds, warehouses, storage areas of workshops	AS 1680.2.4	Table E1, Item 9.7	80 (maint.)
Pump, compressor and machine rooms	AS 1680.2.1	Table D1, Item 9	80 (maint.) 160 (maint.) at switchboards
Process areas (periodic intervention, instrument racks, valve racks, field control panels, field switchboards)	AS 1680.2.4	Table E1, Item 8.1 or equivalent	160 (maint.)
Process areas (frequent intervention, inspection & sampling points)	AS 1680.2.4	Table E1, Item 7.1 or equivalent	240 (maint.)
Switchrooms & control rooms	AS 1680.2.1	Table D1, Item 10	240 (maint.) unattended 320 (maint.) attended
Maintenance workshop assembly/maintenance areas	AS 1680.2.4	Table E1, Item 6.1	320 (maint.)
Laboratories	AS 1680.2.4	Table E1, Item 5.13	400 (maint.)

* Note that lux levels given in the above table are average or maintained (i.e. average multiplied by light loss / maintenance factors) horizontal illuminance levels only and are provided for context. Australian standards apply additional criteria (e.g. minimum horizontal illuminance, vertical illuminance, Colour Rendering Index (CRI) and uniformity) depending on the application. Refer to the standards for these additional criteria.

Maintenance factors shall be applied to lighting calculations as follows:

Area	Standard Applied
Outdoors	AS 1158.3.1
Indoors	AS 1680.4

Lighting levels in vicinity of CCTV cameras shall be selected to support camera operation in low natural light. Care shall be taken to avoid glare within the camera field of view and to ensure uniform lighting within the camera coverage area.

Light pollution, especially regarding light spill onto neighbouring properties, shall be controlled in compliance with AS 4282.

3.7.3 Emergency Lighting

Building emergency and evacuation lighting shall comply to AS 2293 and National Construction Code requirements.

3.8 Lightning Protection

Lighting protection design to AS 1768 is required for new assets and modifications affecting the height and extent of existing assets.

A Risk Assessment (RA) to AS 1768 shall be provided for new structures and modifications to existing structures affecting height or the roofline. If required, a Lightning Protection (LP) Design Report shall also be provided. Urban Utilities assets shall be classified as industrial properties or premises in accordance with AS 1768. Risk assessments shall employ the following methods:

Site Type	Risk Assessment Method
Distributed facilities (e.g. RRCs)	AS 1768 recommended method for distributed facilities
Network sites	AS 1768 Lightning Risk Assessment spreadsheet

RAs and LP Design Report shall include all areas within the site perimeter security fence.

LP Designs shall include drawings containing the following details:

- Overhead earth wire and air terminal installation details and locations
- Down conductor installation details and locations
- LP test links installation details
- Earth grid bonds installation details
- Elevations and site plan view of the rolling sphere zones of protection

The design shall aim to minimise the number of overhead earth wires and air terminals used to achieve the target risk level. Where overhead earth wires and air terminals are required to protect masonry building roofs, coverage shall be demonstrated via the rolling sphere method. An earth electrode with test links shall be provided in proximity to each down conductor. Steel structures, being inherently self-protected, do not require air terminals and down conductors.

Refer to Section 5.7 Protective Earthing and Lightning Protection for installation requirements related to lightning protection.

3.9 Fire Detection Systems

A fire detection system conforming to AS 1670 and AS 4428 shall be installed in new switchroom buildings and for modifications to existing switchrooms, buildings and plant process areas. The fire detection system shall be networkable and

microprocessor based with Fire Indication Panel (FIP) hardwired signals to the site PLC control system.

The fire detection system including VESDA, MCPs and smoke detectors shall be fed from the FIP. The FIP shall be fed from the Essential Services LV Distribution Board.

FIPs shall be capable of a minimum of 8 inputs, 8 outputs and a redundant path network module suitable for multi-mode fibre optic connection to the Master FIP and shall incorporate emergency warning facilities to AS 1670. The existing site master FIP may require modification to allow communications to any new FIPs.

FIPs shall monitor:

- Manual call points
- Smoke detectors
- Other input devices such as VESDA

FIPs shall have direct control over the switchroom building. The status displayed on the FIP local indicator such as warning alarms, faults etc shall be wired through volt free contacts rated at 24VDC to the PLC Control System.

The site PLC control system shall monitor the following FIP signals as a minimum:

- FIP Power On
- FIP General Fault
- FIP Battery Fail
- FIP Fire Alarm
- VESDA General Fault
- VESDA Smoke Alarm
- Any MCP Activated
- Smoke Detector Activated

3.9.1 Point Smoke Detectors

Smoke detectors shall comply with AS 3786.

3.10 Switchroom HVAC Systems

HVAC shall be installed in new switchrooms and as part of modifications to existing switchrooms. HVAC systems shall offer N+1 redundancy, meaning if one HVAC unit is unavailable then the heat load of the switchroom under worst-case operating conditions can be met by the other HVAC unit(s).

The maximum heat load on the building shall be determined by calculation. Calculation and selection of HVAC units shall be approved by an RPEQ Mechanical Engineer. Engineering design software such as CAMEL or equivalent shall be utilised for calculations.

Switchroom HVAC systems shall be designed to maintain the switchroom at 24°C regardless of external ambient temperature fluctuations. This shall be achieved under maximum heat load conditions inside the switchroom (i.e. all switchboards operating at maximum demand).

Switchrooms are not permanently occupied by personnel. The heat load generated from personnel access can be ignored, unless the switchroom is provided with a permanently installed SCADA terminal. In this case the heat load from two persons must be considered in the calculation.

The design of HVAC systems shall consider corrosive conditions where present and mitigate against failure or performance degradation by hardening against corrosion, oversizing or the application of conformal coating.

HVAC units shall meet a design service life of minimum 15 years.

4 EQUIPMENT SELECTION

4.1 General

This section lays out requirements for the selection of and requirements for electrical equipment.

Unless otherwise stated in this Specification, the requirements of TMS60 *Low Voltage Switchboards* apply to LV switchboards and distribution boards supplied with equipment.

4.1.1 Reliability

Type tested, complex, manufactured equipment, such as VSDs, shall be provided with the following information:

- Mean Time Between Failure (MTBF)
- Mean Time To Repair (MTTR)
- Overall MTBF

The methodology used to derive this data shall also be provided.

The information is not required where the proposed equipment is as per TMS62 *Preferred Electrical and Instrumentation List*.

4.1.2 Device Ruggedness

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

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

Panel wiring shall be tinned in SPSs and RRCs.

4.1.3 Primary Nameplate

A stainless-steel main nameplate shall be provided on and permanently fixed to each piece of equipment showing the equipment number and title.

The rating plate shall be fitted in a visible position.

Entries on the rating plate shall be indelibly marked, by etching, stamping or engraving. Text and number markings shall also be visibly coated with paint or powder to provide contrast. Text shall be a minimum of 6mm high.

The following information shall be given in all cases:

- Urban Utilities Equipment Tag Number and description
- Manufacturer's name and Type, Model and Serial Number
- Standard to which apparatus is manufactured
- Technical details required by the relevant standards

Major sub equipment shall be provided with individual nameplates in accordance with applicable Project Specifications and/or the Manufacturer's standard nameplate.

For detailed requirements for signs and labels required during installation, including danger and warning labels, see Section 5.14 Signs and Labels.

4.1.4 Ventilation

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

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

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

The calculation shall consider ambient temperature and component heat dissipation.

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

1. Natural ventilation
2. Solar Heat shield bolted to external walls and shields shall be theft proof.
3. Forced ventilation, with N+1 redundant fans

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

4.2 Cable Selection

4.2.1 Power Cables

Power cables shall be standard types in regular production by reputable manufacturers with supply chains based in Australia. Manufacture of cables shall be copper, circular cross-section unless otherwise specified, with a consistent diameter and profile for the full length of the supplied cable.

Power Cable Type and Design Constraints

Parameter	Details
Performance Criteria	Suitable for installation in water and wastewater facilities with elevated levels of H_2S gas in wastewater facilities and other environmental conditions present. Suitable for installation in HAs where present.
UV Rated Outer Sheath	Where routed outdoors above ground with exposure to direct sunlight
Flame Retardant	Heightened fire risk and other special applications. In accordance with AS/NZS 60332
Fire Resistant	Fire and Gas Detection systems and other special applications
Low Smoke Zero Halogen (<0.05%)	• Control rooms and office buildings • Switchroom light and small power and where both ends of the cable terminate inside the switchroom
Water IP Outer Sheath	Underground cables Double water blocking required for underground cables at sites with a high water table.
Insulation	XLPE/PVC or PVC/PVC
Steel Wire Armoured	Special applications. By approval only.

Cable selection shall consider the ambient air and soil temperature at the site. Derating factors shall be applied as necessary to take account of installation configuration and variation in ambient temperature, in accordance with AS/NZS 3008.1.

Direct buried cables are not accepted under any circumstances.

The design of power cables shall ensure compliance with Section 5.4 Cables.

Refer to TEM336 *Power Systems Analysis Guidelines* for details on power cable sizing calculations.

4.2.2 Instrumentation and Control Cables

Instrument signal cabling shall be PVC/PVC twisted pair with an overall aluminium screen. Individual pair screen cables are also accepted. Each black and white core of the cable shall be numbered and terminated with a suitable crimp at both ends.

Cables with single strand (solid) cores are not permitted.

Stuffing boxes shall be provided as necessary to ensure compliance with hazardous area certification requirements, and to ensure isolation between different hazardous areas (e.g. through an acoustic hood).

Non-intrinsically safe 4-20mA and 24V DC digital cables shall be provided with black sheath.

Where cables are being used on IS circuits, they shall be provided with blue sleeving. Cables for intrinsically safe circuits shall be light blue sheathed (colour B41 to AS 2700AS2700). Cables shall have one outer sheath only, i.e. I.S. cables must not be black sheathed cable over-sheathed with blue, unless approved in writing by Urban Utilities.

Fire and gas system cables shall be Fire Resistant and identified with red strip over the outer sheath.

4.2.3 Cable and Wire Conductor Sizing

Cable and wire conductor sizing shall be as follows:

The minimum cross-sectional area for LV power cables shall be 1.5mm^2.

4.3 Variable Speed Drives

4.3.1 Installation Requirements

VSDs installed inside switchrooms shall be wall mounted.

Dedicated VSD enclosures shall have doors as per the requirements related to control panels laid out in TMS1733 *Control Systems General Specification*.

4.3.2 Performance

The output waveform of the VSD shall be such that motor derating of a standard AC induction motor is not required when operating the driven load by the VSD.

VSDs shall be provided with:

- Capability of starting into a rotating motor, including reclosing the isolation contactor, without tripping
- Automatic restart after momentary power failure
- Torque limiting feature to prevent VSD tripping due to a temporary overcurrent situation
- Slip compensation for maintaining constant motor speed at all loads
- Adjustable acceleration and deceleration times with settings 0 to 1200 seconds minimum
- Auto reset of the VSD after either operator pre-selected or supplier factory set fault conditions. In either case the fault conditions which are auto reset by the VSD and those which may be reset by the operator shall be nominated
- Integral electronic thermal overload
- English language HMI for programming and fault identification
- Capacity to auto-reset/restart up to three times for flushing and anti-clogging with the ability to set time window with manual local reset/restart or remote reset/restart via communications link
- Immunity to transient voltage dips or total loss of supply voltage. Performance level required shall be nominated in project documentation,
- Minimum of two (2) jump frequencies to mask one or more specific speed zones, to avoid driven machinery resonance
- Microprocessor control system for the complete unit, including firing control
- Reprogrammable in the field via a HMI and programming terminal (notebook PC) connected to the VSD communications port

Programmable acceleration and deceleration rates selectable by:

- Volt free contacts
- Communication link
- HMI at the VSD

Motor deceleration shall be controlled by a braking resistor.

The following shall be considered normal requirements:

- Speed accuracy (stability) ±1% from no load to full load
- Maximum speed 50 Hz
- Motor slip compensation
- Starting torque capability to suit load application

- For the power system conditions stated, the VSD shall provide programmable functions to ensure that maximum rated load can be developed by the motor at specified conditions

Design shall take into account the heat generated by all the equipment contained in the enclosure across the full operating range of the VSD.

4.3.3 Accessories

VSD accessories including isolation transformers, input reactors, output reactors and termination filters shall be sized and selected taking into account power supply characteristics and the intended arrangement of equipment, load characteristics, required performance and intended cabling.

4.3.4 Electromagnetic Interference (EMI)

VSDs shall not generate noticeable radio or television interference, nor create electromagnetic interference on the control signal input circuit, internal firing circuit of other control equipment and protection devices.

VSDs shall be compliant with the requirements of AS CISPR 11 Group 1 Class A for radiated emissions.

Design and installation of cabling, wiring and accessories shall minimise EMI, with particular attention paid to:

- Earthing
- Cable / wiring routes
- Segregation / separation
- Shielding

Electromagnetic Compatibility (EMC) filters shall be provided for all VSDs, the category of EMC shall consider the immunity of the drive in the installed environment, should enhanced filtering (c2 category) be required for correct operation these shall be provided.

4.3.5 Audible Noise Emissions

For the full VSD operating range, audible noise emissions from the VSD and associated cooling fans shall not exceed 70 dBA one (1) metre from the source with panel doors closed.

4.3.6 Harmonics Mitigation

VSDs shall comply with harmonic distortion limits as stipulated in AS/NZS IEC 61800.3. The harmonic frequency spectrum of THD current and THD voltage for the full

operating range shall be obtained from the VSD Supplier and included in design documentation.

VSD harmonics shall serve as inputs to the Harmonic Design Report, as required by TEM336 Power Systems Analysis.

4.3.7 Filters

A dV/dt filter shall be provided at the VSD unit where the dV/dt at the motor terminals is calculated to exceed 500V/µs. A dv/dt filter sizing calculation shall be carried out prior to purchase.

4.3.8 Input Contactor

Power to the VSD may be supplied by an input contactor which shall be hardwired to trip the motor based on the following:

- Thermistor relay circuit
- Emergency Stop circuit

Note: an input contactor may not be required where the VSD is provided with the safe torque off feature.

4.3.9 Main Isolator

Each VSD starter shall be supplied with an isolator which shall switch the incoming power supply (3 phase) and auxiliary power supplies. The status of the isolator shall be monitored by the local control system.

- The isolator shall be manually actuated by an external handle with the enclosure door or escutcheon closed
- The isolator unit shall be provided with padlocking facilities for locking the operating handle in the OFF position
- The VSD shall not be damaged if the isolator is opened with VSD operating & motor running
- Any parts inside the VSD starter enclosure which remain live after the isolator is switched off shall be IP2X shrouded against accidental contact and shall be adequately labelled.
- The enclosure or escutcheon door shall be mechanically interlocked to prevent closing the switch when the door is ‘Open’ or opening the door when the switch is ‘Closed’. An interlock defeat mechanism shall be provided and shall be operable only by authorised personnel

4.3.10 Safe Torque Off

VSDs shall support the Safe Torque Off (STO) function according to IEC 61800-5-2 and IEC 62061.

The STO may be used where power removal is required to prevent an unexpected start and typically only for Emergency Stop functions. The STO function shall not be used as a method of isolation to access the VSD or motor.

4.3.11 Configuration General

Programming of functions shall be possible from:

- The on-board HMI without the use of external equipment
- A standard PC running the configuration software
- Using network programming protocols

The VSD shall retain the programmed settings when isolated from its power supply for maintenance purposes or in the event of a power failure.

Provision shall be provided to prevent normal operator access to the VSD's configurable settings and local keypad controls. In particular, the following set points and controls shall be capable of only being accessed by authorised persons during commissioning and fault finding:

- Minimum and maximum frequency setting
- Acceleration and deceleration ramp rates
- Configurable alarm point settings
- Local (keypad) speed control
- Local (keypad) start / stop control
- Other parameters that can affect drive performance
- Adjustable starting torque settings for hard-to-start loads
- A selection of Volt/Hz patterns to ensure optimum operation of the motor/VSD combination
- Independently adjustable minimum/maximum speed limit adjustments
- Minimum of two pre-set speeds selected by digital inputs

4.3.12 Communications

The VSD shall be provided with a communications port capable of connecting to the local control system using one of the communication protocols:

- Profinet
- Profibus
- Modbus TCP/IP
- Serial Modbus

Status and control parameters available at the VSD shall be accessible over the communications link.

4.3.13 Display of Running Parameters

The following shall be accessible individually via the HMI over the communications link:

Control Parameters	Running Feedback	Derived Qty / Other
• Reference Speed (rpm) • Reference frequency (Hz) • Input signal status (run/stop/fault) • Output signal status (run/stop/fault)	• Output frequency (Hz) • Motor actual speed (rpm) • Output current per phase • Output voltage per phase • VSD Internal temperature	• Fault Indications • Power (kW, kVAR) • Power factor • % Load • % Torque

4.3.14 Hardwired I/O

The VSD shall have digital inputs and outputs as follows:

Analog Inputs	Analog Outputs	Digital Inputs	Digital Outputs
• 4-20 mA programmable for speed reference • 0-10 V programmable for speed reference	• 4-20 mA proportional to motor shaft speed	• Run at speed reference 1 • Run at speed reference 2 • Emergency stop Interlock • Forward direction select • Reverse direction select • Electrical fault remote reset • Manual/auto select	• VSD healthy • Running (volt free contact) • Invertor fault (volt free contact) • Input fault (e.g. overcurrent) • Output fault (e.g. motor overload etc)

4.3.15 Alarms

The following shall be provided at minimum:

- A remote common alarm signal (programmable by the user)
- An alarm log system indicating sequence of alarms with time stamping

4.3.16 Fault Indications

Pre-trip information shall be readable from VSD fault memory even following loss power supply. The following fault signals, alarms and trip indications shall be available on the digital display of the VSD and from the communication port on the VSD:

VSD Input Side	VSD Output Side	VSD Internal
• Overcurrent • Overvoltage • Undervoltage • Supply phase failure	• Overcurrent • Earth fault • Electronic motor thermal (inverse) overload protection • Loss of load • Inverter overload • Thermistor trip • RTD trip	• DC bus overvoltage protection (against regenerative voltages) • DC bus undervoltage • VSD overtemperature • Braking resistor overheat • CPU fault • Backup battery failure

4.3.17 Diagnostic Features

The VSD shall have diagnostics capability, with memory of the last three faults (or more), available via the HMI.

The HMI shall allow access to authorised persons only (password protected) to configure and read the following data:

- Current limit
- Acceleration and deceleration rates
- Hold speed settings, jump or speed range masking and related speed control features
- Overload or invertor firing fault
- Motor overload settings

4.3.18 Protection

VSDs shall be fitted with all necessary internal protection to ensure safe operation of the unit.

A list of protection settings for VSDs shall be provided so that these can be verified and witnessed during the Factory Acceptance Test.

Reset of VSD faults shall be manual from the HMI and via the communication link or using hardwired signals.

VSDs shall trip under the following internal fault conditions:

- Converter and inverter stage power and control circuit failure
- Earth fault on the output

- Output single phasing
- Fan failure and/or high enclosure temperature

Input contactor trips or the Safe Torque Off feature (refer to Section 4.3.10 Safe Torque Off)shall be used where safety related functions are required.

VSDs shall have the following motor protection features:

- Motor current thermal overload protection
- Temperature winding high alarm and trip (RTD / thermistor)
- Stalled / Locked rotor protection
- Unbalanced current protection
- Starts per hour
- Instantaneous earth fault

The output of VSD shall have an earth leakage protection scheme enabled.

Where utilising an existing motor compatibility of existing temperature elements with the VSD proposed shall be confirmed. Replacement of temperature elements shall take place as required.

4.3.19 VSD FAT Requirements

Test certificates for type tests establishing the performance criteria of the VSD and enclosure in accordance with the requirements of AS 60146 and AS/NZS61439.1 are required.

Routine tests in accordance with AS 60146.1.1 and other relevant Australian Standards shall be performed at a minimum. These shall be performed as part of the Factory Acceptance Test.

Each VSD shall be functionally tested with a small 3 phase motor connected and supplied for this purpose. The VSDs shall be programmed to suit the test motor and all operating functions shall be checked with the test motor in operation. Parameter settings for the test motor and site motor shall be provided in the FAT Report. The VSD communication link and remote control and monitoring of the VSD over the network shall be fully tested.

4.4 LV Motors

Refer to TMS1639 *General Mechanical Specification* for selection criteria for LV motors.

Motor starting analysis shall be undertaken to determine the voltage drop when starting large motors as per TEM336 *Power Systems Analysis Guidelines*.

Motor starting shall be via an OEM-approved motor starter arrangement.

4.4.1 LV Motors for Hazardous Areas

Where motors are required to operate in Hazardous Areas the motor data sheet shall nominate the protection technique in accordance with AS 60079.

The motor's certificate of compliance with AUSEx, ANZEx or IECEx shall be supplied with the motor datasheet. Special attention shall be made to motors with VSD and soft starters in Hazardous Areas where the combination of starter and motor requires certification. The motor and starter shall have additional levels of protection against ignition of a flammable/explosive atmosphere in accordance with Australian Standards. Refer to Sections 3.6 Hazardous Areas, 5.13 Hazardous Area Installation and 5.14.2.1 Hazardous Area Labels for further requirements.

For motors certified for use in Hazardous Areas, the embedded winding RTDs shall be included in the motor certification and shall be of a suitable protection method. The use of intrinsically safe (I.S.) RTDs requiring external energy limiting devices is not permitted.

Thermal detector circuits installed on motors located in Hazardous Areas shall comply with and be certified for HA applications.

For bearing temperature detectors, care shall be taken that the RTD element does not violate the integrity of any bearing insulation.

Motors installed in Hazardous Areas provided with multiple cable entries may leave cable entries unused. The decision as to which entry to use will be made at site when cable connections are completed. To ensure unused cable entries remain sealed with an appropriately certified stopper plug, all entries shall be fitted with appropriate seals prior to shipment so that only the requisite seals are removed at the time of site cable connections. Where the choice of cable entry is unambiguous it may be appropriate to seal the cable entry with a temporary plug which would be replaced with a suitable cable gland on installation.

Drain holes will be provided in the motor's stator enclosure where water might collect as per AS 60034-5. Motors installed in Hazardous Areas shall have drain holes sealed with an Ex certified bung.

4.5 Uninterruptible Power Supplies

4.5.1 General Requirements

230V AC UPS systems shall take one of the following forms, depending on criticality and application:

System Type	Description	Example Applications
Standalone	Non-expandable, self-contained UPS system held within a single enclosure.	Lower criticality applications where controlled shutdown of equipment upon loss of power is the driver (e.g. sites that fail-safe into gravity-flow operation or UPS serving specific equipment)
Modular	Expandable system made from self-contained power modules installed in racks. Often configured for expandability or additional redundancy.	Lower criticality applications where controlled shutdown of equipment upon loss of power is the driver of UPS type and where expandability is required (e.g. control rooms)
Industrial	Expandable system made from components hardened against harsh industrial conditions. Components are often separated rather than held within modules.	Critical process applications where continuity of service is the driver (e.g. switchrooms at RRCs)

It is permissible at Network sites to have a single battery backup (e.g. DC power supply unit and DC UPS module with integral battery) in lieu of a feed from a dedicated AC UPS.

A criticality assessment with input from Urban Utilities operations stakeholders shall be carried out when determining the appropriate UPS system type for each application.

UPS systems shall be designed, constructed and tested as per AS 62040.1, AS 62040.2 & AS 62040.3.

Industrial UPS enclosures shall be constructed to the following minimum requirements:

Parameter	Indoor Panel
Minimum IP Rating	IP42 (doors closed) IP21 (doors open)
Form of Separation	Form 1
Minimum Material Grade & Thickness	1.6mm Zinc-plated steel
Fasteners	Zinc-plated mild steel
Spare Space	20% for future terminals, gland plate holes
Colour	RAL 2000 or AS2700 X15

UPS system internal wiring and earthing shall conform to the requirements for Control Panels laid out in TMS1733 *Control Systems General Specification*. Refer to Section 5 Installation for requirements regarding cable entry and cabling external to enclosures.

Refer to Section 5.15.20 UPS System Testing for details on inspection and testing for UPS systems.

4.5.1.1 Installation Requirements

UPS systems shall be installed in restricted access areas according to the meaning and requirements of AS 62040.1, meaning restricted to access by ordinary persons (e.g. switchrooms, data rooms or lockable communications cabinets). UPS systems shall be installed as per Section 5 Installation.

For complex sites (e.g. RRCs), each switchroom requires a dedicated UPS. Small dedicated UPS for specific equipment or- distributed throughout these sites will be considered only where the localised load is small, low criticality and it is not economically feasible or practical to install an LV supply fed from a larger centralised UPS in the nearest switchroom.

UPS systems and batteries shall not be installed outdoors.

4.5.2 UPS Configuration

UPS systems shall be of the double conversion type, incorporating static bypass functionality.

UPS systems shall incorporate a maintenance bypass switch, separate to the system.

UPS System configuration shall incorporate redundancy to meet the criticality requirements. Depending on criticality, this may include redundant supplies, rectifiers, inverters or chargers. Criticality shall be determined by risk assessment.

4.5.3 UPS Input Specification

UPS systems shall conform with the input specification requirements laid out in AS 62040.3.

UPS systems shall be designed to receive power from two AC power supplies to be fed into the following inputs:

- Normal AC input – supplies the AC UPS under normal operating conditions
- Static Bypass AC input – supplies the AC UPS DB in the event of UPS shutdown (failure) or an overload (short circuit, high inrush currents etc.)

The following conditions shall be met as a minimum:

- Protective devices on the incoming AC supply shall be compatible with the protection characteristics of the upstream power distribution system
- Connection to the MEN shall be maintained via the neutral conductor

The following conditions shall apply to industrial grade UPS systems:

- All poles, including the neutral, shall be able to be isolated from the incoming supply
- UPS shall be capable of receiving supply from two independent sources (e.g. mains & generator supply)
- Systems shall be capable of tolerating, or be protected from, high inrush current upon start up

4.5.4 UPS Output Specification

UPS output shall comply with Section 5.3 of AS 62040.3.

The output supply of the AC UPS shall have a solidly earthed neutral at the voltage and frequency nominated in Project Documentation.

UPS output shall allow operation with load CBs incorporating earth leakage protection.

UPS shall meet special conditions defined in Project Documentation, which may include:

- Compatibility with special AC loads or loads generating harmonic currents
- Load distribution by an AC distribution board
- All-pole isolation of the UPS from the load
- MEN connection via the neutral maintained for loads in all modes of operation

4.5.5 Performance Classification

Refer to section 5.3.4 of AS 62040.3.

Industrial UPS shall be classified as VFI SS 111, where:

Characteristic	Code	Description
Input dependency	VFI	Output voltage and frequency are independent of supply (mains) voltage and frequency variations
Voltage dependency	SS	The AC output voltage waveform is sinusoidal, with total harmonic distortion ≤ 8 % and individual harmonic distortion within limits of AS 62040.3 Table 2 – for both normal/bypass mode or stored energy mode.
Dynamic output performance	111	The UPS output voltage is completely uninterrupted (i.e. remains within the limits of curve 1 of subclause 5.3.4 to AS 602040.3) when the system experiences a change of mode of operation, a linear load step application, or a non-linear load step application

Minimum performance classification of standalone and modular UPS system types shall be VFI SS xxx, where dynamic output performance is selected based on typical load behaviour and tolerances.

4.5.6 Batteries

Batteries shall be located, ventilated, protected and marked as per AS 62040.1.

4.5.6.1 Battery Type

The following requirements apply:

- Nominal battery voltage shall not exceed 24V DC
- Battery banks shall consist of identical cells or modules (same model numbers)
- The preferred types of battery cell are Lithium Ion Phosphate or Valve Regulated Lead Acid (VRLA) batteries

4.5.6.2 Battery Compartment and Battery Room Ventilation

Rooms and compartments with VRLA batteries shall have adequate ventilation to prevent hydrogen gas accumulation in accordance with AS/NZS 62040. Hydrogen dissipation calculations shall be provided.

4.5.6.3 Battery Access and Maintenance

In non-modular systems, access panel/doors shall be sized to allow removal of the batteries. Large batteries shall not require lifting for removal and shall be preferably placed in a separate rack/enclosure or drawers.

4.5.6.4 Battery Back Up Time

Required battery backup time shall be determined based on a criticality assessment that has considered supported systems and time required based on the logistics to provide a backup power source. Backup times shall be calculated for maximum demand at end of battery design life.

4.5.6.5 Battery Capacity

UPS equipment shall be sized for:

- Maximum demand for the design load
- Spare capacity to allow for 20% load growth

The battery bank shall have the capacity to repeatedly provide the discharge duty based on the load profile and requirements specified in Project Documentation.

Minimum end of discharge voltage shall be as per Project Documentation.

4.5.6.6 Battery Age Compensation

Batteries shall be suitable for a minimum 10-year design life. Estimated battery life at the nominal design temperature shall be stated in Project Documentation.

The nominal ampere-hour capacity shall compensate for ageing and temperature effects.

Except where end-of-life capacity is determined using empirically derived capacity curves, new battery capacity shall not be less than 125% of the nominal ampere-hour capacity required to fulfil the performance criteria specified, after allowing for 20% load growth.

$$New\ battery\ capacity\ is:$$
$$\geq \left(\left(120\%\ design\ load\ (Amps) x\ backup\ time\ (hrs)\right) x\ 125\%\ age\ compensation\right.$$
$$\geq 150\%\ of\ design\ capacity\ (Amp-hrs)$$

4.5.6.7 Battery Connection Arrangement

Non-modular battery banks shall consist of multiple battery strings in parallel, so individual cell failure does not render the entire battery bank unavailable.

4.5.6.8 Battery Isolation and Protection

It shall be possible to isolate batteries or power modules for replacement or maintenance without shutting down the battery chargers or disconnecting the load.

Each battery bank shall be supplied with a 2 pole, suitably rated DC circuit breaker functioning as a device for isolation and overcurrent protection.

4.5.6.9 Temperature Sensors

Where required, temperature sensors for monitoring battery cells shall be securely mounted. Fixing with double sided tape is not accepted.

4.5.6.10 Battery Markings

The requirements of section 6 of AS 62040.1 shall apply. In addition:

- Operator-accessible batteries shall be marked with part numbers, volt and amp/hour rating
- Battery cells or modules shall be individually marked with their installation date using permanent marker

4.5.6.11 Battery Monitoring System

A Battery Monitoring System (BMS) shall be incorporated into the battery system design and be capable of monitoring each cell. Measured information shall be displayed locally at the equipment HMI. The BMS shall communicate with the site control system and shall log all measured data.

4.5.7 Rectifier/Chargers

Battery chargers and rectifiers shall protect batteries from damage by managing starting current, overcurrent, inverter ripple currents, battery voltage (i.e. excess charge/ discharge) and changes to input conditions (e.g. AC power supply failure). Batteries shall be protected from reverse polarity by physical means or by detection and disconnection.

Battery charge/discharge cycles for critical systems shall be managed in a way that extends battery life. Continuous trickle charging (float charging) is acceptable for low-criticality UPS systems.

Maximum battery recharge time (full discharge to 90% charge) shall be ≤12hr, unless constrained by battery technology.

Details of upstream protective devices (CB current ratings etc.) shall be specified for each UPS.

'Soft-start' capability shall be provided to eliminate overcurrent during starting by gradually accepting load until nominal conditions are reached.

4.5.8 Inverters

Inverters shall be sized to supply the design maximum demand with allowance for 20% future increase in load.

Inverters shall supply sufficient short circuit current to cause operation of the largest output circuit protective device within half a cycle.

Inverters shall be protected from inrush current, overcurrent, output short circuits, abnormal input conditions and output overtemperature. Reverse polarity protection shall be achieved by physical means or by detection and disconnection.

4.5.9 Static Bypass Switch

Static bypass switches shall allow instantaneous transfer of the load between the inverter and the static bypass power supply. Transfer shall not interrupt or disturb supply to the load.

4.5.10 Maintenance Bypass Switch

Maintenance Bypass Switches (MBS) shall allow instantaneous transfer of load between the UPS and the mains supply to isolate the UPS for maintenance purposes.

MBSs for industrial UPS systems shall be located in a separate enclosure near the UPS. The switch and enclosure shall comply with AS 60947.3. Means to completely disconnect power to the load shall be provided, either integral to the MBS (i.e. an "OFF" position), or via a separate isolator adjacent to the MBS. It shall be possible to lock the switch or isolator in the "OFF" position.

An engraved descriptive label shall be fixed on or adjacent to the maintenance bypass switch enclosure providing instructions for operation.

4.5.11 Backfeed Protection

UPS systems shall incorporate backfeed protection to prevent hazardous energy from being present on the UPS input AC terminals after interruption of the input AC power.

If backfeed protection is provided externally, an isolating device and installation instructions shall be provided. Warning instructions shall be fixed near output terminals warning operators that isolation is required before working on remote supplies fed from the UPS.

4.5.12 Isolation Transformers

UPS systems shall incorporate isolation transformers as per the installation conditions outlined in Project Documentation and manufacturer recommendations. Isolation transformers on either the input or output of the UPS system are typically employed to achieve the following:

- To allow the main or bypass supply to incorporate earth leakage protection that would otherwise be subject to nuisance trips from circulating neutral currents
- To segregate the neutrals of the main and bypass supplies from one another when these are derived from independent sources (e.g. consumer mains and generator; or two electrically separate consumer mains)

4.5.13 Accessibility

Safety interlocks shall be provided for areas where operators have access.

The rear of the enclosures shall be suitable for installation against a wall. The enclosure shall be fully accessible from the front, conducive to servicing, adjustments and component replacement.

Equipment and components shall be arranged in compartments, so discrete parts can be isolated and made safe for maintenance work with the remainder of the system in service.

4.5.14 Capacitive Discharge

Capacitors and capacitive components shall have a means of discharge for protection of service persons fitted. If discharge time exceeds 1s, a warning label stating discharge time shall be added.

4.5.15 Earthing

Industrial UPS enclosures shall have an internal earth bar.

MEN connection via the neutral shall be maintained for loads in all modes of operation.

4.5.16 Measurement, Control and Communications

UPS systems shall have a Modbus TCP/IP communications interface to the local control system to provide status information, measurements, calculated parameters, alarms and controls to SCADA. Sub system module (e.g. BMS or separate MBS) information shall use the same link.

4.5.16.1 Local Display

Indication of system status, supply sources, battery health and operating mode shall be provided locally at the UPS via OEM standard products (e.g. HMI) or panel mounted lights.

Measured quantities shall be accessible locally at the UPS.

4.5.16.2 Hardwired Signals

Industrial UPS systems shall repeat critical output signals to the local PLC as voltage free contacts:

Status Signals	Alarms
UPS operation healthy AC power available Bypass mode Battery mode	Common alarm (grouped common alarm including Modbus alarms)

Hardwired signals shall be configured as fail safe.

4.5.16.3 Alarms & Status via Modbus Link

UPS systems shall make the following available via a Modus TCP communications link:

Status Signals	Alarms
AC input current	Normal input AC power supply failure
AC load voltage	Bypass input AC power supply failure
AC load current	Rectifier / charger failure
Battery charge/discharge	Battery disconnected
Switched to Bypass operation	Battery charge failure
	DC earth fault
	Inverter failure
	AC output overvoltage / undervoltage
	Inverter overcurrent
	Synchronisation loss
	Control circuit fault
	AC output supplies lost
	High cabinet temperature

4.5.17 Acknowledgement and Resetting of Alarms

Where “Local” means at the UPS and “Remote” means at the PLC HMI or a remote SCADA terminal:

- Remote resetting of critical alarms shall not be permitted
- Remote alarms shall be automatically reset when the local alarm indication is manually reset
- Alarm initiated lights shall remain asserted until manually reset
- Acknowledgement of an alarm locally or remotely shall supress audible alarm tones but shall not reset the alarm.

4.5.18 Site Support

After-sales support capability shall be a consideration in UPS system product evaluations. Contact details of the nearest service representative for the equipment shall be stated on O&M manuals or otherwise obtained from Suppliers.

4.5.19 Primary Nameplate

In addition to the requirements of Section 4.1.3 Primary Nameplate, the nameplate shall contain:

- Year built
- Total Certified Weight (kg)
- Battery Cell certified weight (kg)
- Battery Rated Temperature (min. and max. range)
- Rated output voltage
- AmpHr rating
- Battery type, battery cell volts and cell amp-hour rating

4.5.20 Other Labels

In addition to the requirements of Section 5.14 Signs and Labels, a label, white background with black text, shall be installed with instructions on how to operate the MBS and any other isolation devices.

Terminals for connection of external cables shall be clearly identified.

4.5.21 UPS FAT Requirements

Verification shall be undertaken as per the following:

Purpose	Standard	Reference
General & Safety Requirements	AS 62040.1	Section 5.1.7.101 Table 22
Electromagnetic Compatibility	AS 62040.2	Section 5.2 Annex A
UPS-specific tests	AS 62040.3	Section 6.1.6 Table 3

UPS systems serving critical infrastructure (e.g. RRCs, large network sites), shall undergo additional tests to AS 62040.3:

- Stored Energy Time Test
- Restored Energy Time Test

AC UPS systems shall undergo both Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT). Generally, FAT will demonstrate performance of functional units (system components) and SAT will demonstrate performance of the completed system, with any AS 62040.3 routine tests not completed at FAT being performed as part of SAT.

4.6 DC Power Supplies – General Use

Batteries for the DC system shall be suitable for a minimum 10-year design life. DC power supplies outside HV switchrooms shall be 230V AC/24V DC units selected from TMS1151 *Preferred Equipment List – Control Systems*.

DC power supplies at complex sites shall take input AC power from a UPS-backed distribution board. Network sites may have a battery backup (e.g. DC power supply unit and DC UPS module with integral battery) in lieu of a feed from a dedicated AC UPS and a minimum 8 hours back-up time at maximum demand and at end of battery cell design life shall be provided.

For complex sites DC power supplies shall meet the following requirements:

- Installed in a dedicated enclosure (not contained within an LV switchboard or MCC)
- Incorporate redundancy to ensure a faulty power module does not interrupt operation
- Capability to safely isolate and remove faulty power modules without interrupting operation
- Status monitored by the local control system

For small sites, DC power supplies shall meet the following requirements:

- Installed in the PLC control panel where space permits, or in a dedicated enclosure
- For Network assets, provided to Urban Utilities standard drawings

4.7 DC Supplies - HV Switchrooms

DC power supply systems used in HV switchrooms shall provide a single common system supplying all control, monitoring and communications loads within the switchroom.

Parameter / Component	Requirement
Input	400V AC three-phase for loads > 7.5kVA 230VAC 50Hz single phase for loads ≤ 7.5kVA
Output	24V DC Other voltages as per Project Documentation (special applications only)
Rectifiers / Chargers	2 x rectifiers/chargers in parallel redundant configuration Compliant to the AS 60146 series or AS 4044
Changeover Switch	Double-pole, make-before-break A, A+B, B configuration (i.e. load supplied by either charger, or both in parallel)
Batteries	2 x 24V DC battery strings (each at 50% capacity) A minimum 8 hours back-up time at maximum demand and at end of battery cell design life shall be provided.
Inverters / Converters	As required for outputs other than 24V DC 2 x inverters/converters in parallel redundant configuration Class A inverters as per AS/NZS 5603; Alternatively, inverters and DC converters as per AS 60146
Distribution Boards	As required for outputs other than 24V DC Double pole breakers required

The battery charger shall be supplied from the essential services AC supply.

Battery systems shall meet the requirements of Section 4.5.6 Batteries.

Rectifiers and chargers shall meet the requirements of Section 4.5.7 Rectifier/Chargers.

Protection for inverters shall be as per Section 4.5.8 Inverters.

Safety measures for capacitive discharge shall be as per Section 4.5.14 Capacitive Discharge.

DC-DC converters shall:

- Include a transformer to provide galvanic isolation between input and output
- Be capable of operating continuously under load variation of 0-100% of rated output
- Have protection as per Section 4.5.8 Inverters and output current limiting with hiccup mode

Protection systems shall provide discrimination from source of supply through to load.

Protection against overcurrent and excessive internal temperature rise shall be provided.

Inspection and testing shall be as per Section 5.15 Quality Assurance, Inspection and Testing.

4.7.1 Primary Nameplate

In addition to the requirements of Section 4.1.3 Primary Nameplate, the nameplate shall show:

- Year built
- Total Certified Weight (kg)
- Battery Cell certified weight (kg)
- Battery Rated Temperature (min. and max. range)
- Rated output voltage
- AmpHr rating
- Battery type, battery cell volts and cell amp-hour rating

4.7.2 Safety Labels

Battery chargers shall bear a shock hazard label and other safety markings as per AS 4044.

Warning labels shall be applied as per Section 5.14.3 Danger and Warning Labels.

4.7.3 Enclosures

Custom DC Power Supply enclosures shall be constructed as per the following:

Parameter	Indoor Panel
Minimum IP Rating	IP42 (doors closed) IP21 (doors open)
Form of Separation	Form 1

Parameter	Indoor Panel
Minimum Material Grade & Thickness	1.6mm Zinc-plated steel
Fasteners	Zinc-plated mild steel
Spare Space	20% for future terminals, gland plate holes
Colour	RAL 2000 or AS2700 X15

Enclosures shall prevent tampering by unauthorised persons. Potentiometers, rheostats or other physical controls used to adjust the output characteristic of a battery charger shall require a tool for access.

Internal wiring and earthing shall conform to the requirements for Control Panels laid out in TMS1733 *Control Systems General Specification*. Refer to Section 5 Installation for requirements regarding cable entry and cabling external to enclosures.

A separate or segregated enclosure is required for the battery bank and charger.

Ventilation shall be provided as per Section 4.1.4 Ventilation.

The main DC cable in battery banks shall be flexible type and be lugged. Hard drawn cables are not accepted in battery banks. Flexible cables shall be long enough to rack out battery racks or drawers.

Batteries' negative supply shall be earthed.

4.7.4 Measurement, Control and Communications

DC Power Supply systems shall be supplied with all the necessary equipment to facilitate operation and control of the equipment in accordance with this Specification.

Remote access allowing fault analysis from external locations shall be provided.

4.7.4.1 Local Display

Indication of system status, sources of supply, battery health and mode of operation shall be provided locally, either via OEM standard products (e.g. HMI) or panel mounted lights.

Measured quantities shall be accessible locally at the DC Power Supply.

4.7.4.2 Hardwired Signals

The following hardwired signals shall be provided via volt-free contacts:

Status Signals	Alarms
Running / System normal Battery charger operation healthy	System general fault Common alarm (grouped common alarm incl. Modbus alarms) Battery charger fault alarm Battery charger output failure Low DC float voltage High DC float voltage AC power failure alarm Converter / Inverter fault

Facilities shall be provided to enable a system normal running and system general fault status to be remotely monitored by a PLC input by means of voltage free contacts.

Additionally, there shall be provision and wiring for minimum 6 off voltage free contacts that are configurable should additional status signals be required in future at the local PLC.

4.7.4.3 Alarms & Status Via Modbus Link

The following shall be available via a Modbus TCP communications link.

Battery Charger Status	Battery Charger Alarms	BMS Alarms / Signals
Charge Voltage Charge Current Load Voltage Load Current Battery set 1 Charge/Discharge Battery set 2 Charge/Discharge	AC input supply failure Rectifier / charger failure DC low voltage DC high voltage DC under/over voltage trip Battery charge failure Battery disconnected DC earth fault Current-limit mode operating Control circuit fault High cabinet temperature or ventilation fan failure	Cell temperature Cell impedance (Ave/Min/Max) Depth of discharge (Ave/Min/Max) Battery capacity remaining Time to low voltage Discharge current (Ave/Max) Charge current (Ave/Max) Deepest discharge Level No. of deep discharge events Time in deep discharge (Ave/Max)

Where the BMS cannot monitor/measure the above directly, alternate means (e.g. a method to calculate the items based on available measured values) shall be provided.

Inverters and Converters shall make the following available via a Modbus TCP communications link:

Inverter & Converter Signals
Fault
Output Voltage
Input Voltage
Input Failed

4.7.4.4 Controls

At minimum, the following control facilities shall be provided:

Buttons & Switches	Other Controls
Rectifier / charger A / B on/off switch	DC float voltage adjustment
Rectifier / charger A / B isolation switch	DC output voltage adjustment
Load transfer initiating control switch	DC current limit adjustment
Battery A / B isolation breakers	
Alarm acknowledge	
Alarm reset	

4.7.4.5 Acknowledgement and Resetting of Alarms

Where "Local" means at the enclosure and "Remote" means at the PLC HMI or SCADA terminal:

- Remote resetting of critical alarms shall not be permitted
- Remote alarms shall be automatically reset when the local alarm indication is manually reset
- Alarm initiated lights shall remain asserted until manually reset
- Acknowledgement of an alarm locally or remotely shall supress audible alarm tones but shall not reset the alarm

4.8 Transportable Switchrooms

Refer to TMS1188 *Transportable Switchrooms* for modular or transportable shipping container switchrooms.

4.9 Transformers

The design requirements for oil insulated transformers are included in TMS1185 *Distribution Power Transformer (Less than 5MVA)*. Additional requirements are as follows:

- Transformer compounds shall have security fence with lockable access gates
- Transformers shall be concrete plinth mounted within a bund area. Bund capacity shall be ≥110% of total tank volume plus fire fighting requirements as per AS 2067
- Transformer compound clearances shall be as per AS 2067

- Compounds shall have a sump pit to allow removal of oil and/or water
- A 2-hour fire rated wall shall be provided between adjacent transformers
- Where transformers are installed adjacent to a non-fire rated building, a 2-hour fire rated wall shall separate the building and the transformer compound
- Compounds shall be filled with aggregate to ≥150mm depth and retained by concrete walls
- Transformers may be enclosed "kiosk" pad mount type compliant to AS 62271.202, totally enclosed with an integral bund. A fence is not required for this type of installation
- Noise walls shall be provided where required to meet the site noise emission constraints

Where cost effective and practical to meet the project requirements dry type transformers are accepted and design requirements are included in TMS1625 *Dry Type Distribution Transformers*.

Special consideration for ventilation is required where transformers are in outdoor enclosures.

Pole mounted transformers are not accepted.

4.10 Diesel Generators

Refer to TMS1589 *Low Voltage Diesel Powered Generators*.

Permanently installed generators shall consider arc flash incident energy at the alternator terminals. Generator local HMIs shall be placed outside the arc flash boundary. System components, including the alternator and on-board switchgear are not typically housed in arc fault contained enclosures.

Refer to TEM336 *Power Systems Analysis Guidelines* for generator arc flash hazard assessments.

Permanently installed generators shall employ load shedding / demand control schemes where required. Unless specified otherwise, load shedding shall be implemented in the local PLC in accordance with TMS1733 *Control Systems General Specification*.

4.11 Solar Photovoltaic Systems

4.11.1 General

Solar system design shall be undertaken to Australian Standards by Clean Energy Council accredited RPEQ engineers. Only equipment on the Clean Energy Council list of approved products may be used.

PV systems shall be installed in accordance with the *Clean Energy Council Install and Supervise Guidelines for Accredited Installers*. Where grid connection is required,

applications, negotiations with the Supply Authority (Energex) and other activities required to connect the PV system to the grid shall be undertaken.

Total harmonic distortion at the installation's point of connection to the grid shall not exceed the limits laid out in TEM336 *Power Systems Analysis*.

4.11.2 Inverters

Inverters shall be 3-phase, transformer less type in compliance with AS/NZS 4777. The following additional requirements apply:

- Inverters shall be sourced from OEMs with registered distributors in Australia
- Inverter warranty shall be unconditional and ≥10 years for industrial use
- Inverter enclosures shall be minimum IP4X
- Inverters shall be wall mounted indoors or otherwise protected from weather or direct sunlight
- Inverters shall accept multiple strings of PV panels
- The inverter shall connect directly to the site LV main switchboard through a 3-pole CB
- Inverters shall be provided with a Cat6 communications port, support Modbus /TCP and shall interface with the site control system for diagnostics and status monitoring via SCADA
- Hybrid inverters to charge batteries are not required, however the system shall be expandable to include battery connections or additional inverters in future

4.11.3 Photovoltaic Panels

PV Panels shall be sourced from OEMs with registered distributors in Australia, approved and comply with the following:

Parameter	Requirement
Manufacturing Quality System	Compliant with EIC 62941
Panel Type	Monocrystalline PERC or similarly high efficiency / power density type
Design Life	25 years
Warranty Period	≥12-year unconditional warranty under industrial conditions
Ingress Protection	IP65 for electrical connections, IP 2X for connections mounted inside an enclosure
Power Output Degradation	≤2.5% (1st year), then ≤0.6% per year up to year 25 (i.e. ≥83.1% output at year 25)
Power Temperature Coefficient	<0.4%/°C
Power Tolerance	+3%/-0%
Voltage Temperature Coefficient	<0.3%/°C
Current Temperature Coefficient	<0.06%/°C
Panel efficiency	≥20%
Corrosion Resistance	Salt Spray test compliance IEC 61701 (maximum severity)
Impact Resistance	25mm diameter hail at 23m/s

Parameter	Requirement
Wind Rating	2400Pa, 240kgm^2 front and back

Designs shall comply with AS/NZS 5033 and the following additional requirements:

- PV panels shall be connected in multiple strings
- Panels shall be mounted on fixed, permanently installed, galvanised steel structures
    - Other mounting methods may be considered and shall be accepted and fully costed before works commence
- Small kW systems (≤10kW) are permitted on building rooftops
    - Permanent access to the rooftop shall be provided to the relevant design standards and included as part of the design.
- Arrays shall be arranged for optimum solar exposure
- Array design shall avoid direct reflection onto residential dwellings and roadways
- The area under and around the panels shall be a low maintenance surface treatment and accessible to control weeds
    - Equipment shall not be susceptible to mechanical damage from machinery and power tools required to control vegetation under the structures

4.12 Instrumentation

4.12.1 General

Instrumentation signal types shall comply with the following table:

Parameter	Signal Type
Operating Voltage	24VDC
Analogue I/O Signals	4-20mA
Digital I/O signals	24VDC volt free
Process Communication Signals	Modbus TCP DNP3 HART Ethernet/IP

Note 1: 230V AC single phase supply to instruments, process control solenoids and motorised actuated valves shall only be proposed where the 24V DC supply option is not cost effective or t technically practical and must be accepted by Urban Utilities in writing. An RCD shall be provided at the point of supply to all equipment that requires an LV supply.

Note 2: Profibus and Profinet are only accepted where minor modifications to an existing control system network are required and only where the protocols are already in service at the site.

4.12.2 Instrument Operating Range

Instruments shall be factory calibrated. The operating range and set points shall be included in the project instrument schedule. Refer to FOR893 *Instrument Schedule* for a typical instrument schedule template.

In the absence of an instrument datasheet template included with Project Documentation, instruments shall be provided with the manufacturer's generic datasheet. Information on the datasheet not applicable to the instrument supplied shall be marked as such.

For instrumentation installed at various Network Asset types refer to the asset type functional specification documents.

4.12.3 Installation and Interconnections

Typical instrument process connection or hook-up drawings shall be provided for all instruments to be supplied or modified.

P&IDs shall be provided for all projects where new or modification to existing instrumentation is required. As-Built P&IDs for existing assets shall be produced where Urban Utilities is unable to provide the P&IDs.

4.12.3.1 General Requirements

For instruments not specified in Project Documentation, selection shall be based on TMS62 *Preferred Equipment List Electrical and Instrumentation*. Deviations from this list will be assessed for acceptance by Urban Utilities based on proven field performance and OEM technical support.

Smart HART analogue transmitters shall be used in place of analogue transmitters that use DI status feedback wherever possible. Process variable alarming or switching shall be achieved via software alarms and switches configured in the local PLC.

Instrumentation in safety applications shall be provided with dedicated process tapping points separate from tapping points for normal control services.

Monitoring and recording of data of process variables shall be performed by the site control system.

Field transmitters shall be provided with integral digital indication.

Loop powered local indicators mounted externally to transmitters shall be local to the transmitter and not reside in cable junction boxes or local control panels.

PLC-based control systems shall be utilised. Local field controllers shall only be used where accepted by Urban Utilities.

The materials of construction shall be suitable for the process conditions. Where there is a conflict between suitable materials of construction and this document, the suitable material shall take precedence, unless otherwise approved by Urban Utilities.

DC relays shall be fitted with free-wheeling diodes. Solenoid coils shall also be fitted with suppression protecting diodes, located within the local control panel.

Instruments shall be installed to enable calibration and testing without shutting down the process.

Instruments shall be lagged, or heat traced and lagged, where the process liquid would otherwise condense, solidify or be otherwise adversely affected by low or high ambient temperatures.

Density measurement methods shall be accepted by Urban Utilities. These shall have a track record of accuracy and repeatability in similar service conditions in the water industry.

Analog field instrumentation shall be individually fused at the point of supply by a suitably rated fuse.

4.12.4 Flow

4.12.4.1 Vortex Meters – Volumetric Flow

Particular attention shall be paid to the minimum flow of a vortex installation to determine suitability for application. Where vortex flowmeters are used, the Reynolds number at minimum flow shall not be less than 20,000.

4.12.4.2 Differential Pressure – Volumetric Flow

Flow orifice plates and orifice plate flow meter installations shall comply with AS 2360. The preferred material for orifice plates is 316SS. However, materials shall be compatible with the fluid handled.

For liquids with entrained solids, eccentric orifice plates may be used subject to the acceptance of Urban Utilities. Alternate design (multi-hole) orifice plates which may reduce the straight run piping requirements may be used subject to the acceptance of Urban Utilities. No Drain and/or weep holes shall not be made in any flow orifice plate. Square root extraction shall be performed in the transmitter. Use of straightening vanes shall be subject to the acceptance of Urban Utilities.

The flow rates and choice of differential pressure transmitters shall be as follows:

- Normal flow rate shall be between 70% and 80% of the full-scale flow provided that the anticipated minimum and maximum flow rates shall be between 33% and 95% of the full scale flow and the accuracy of the transmitter is at least 0.2% of the calibrated span

- Where the required range is required to be between 33% and 95%, a single transmitter may be used
- Where the required range is exceeds 33% and 95%, dual transmitters may be required and shall be submitted for approval
- Differential pressure transmitters providing safety functions shall have a range such that the trip point is at least 33% of the full-scale calibrated span
- Orifice plate Beta ratios (orifice diameter/pipe inside diameter) shall be between 0.3 and 0.7
- The preferred DP cell range is 25 kPa. Common alternatives are 10 kPa & 50 kPa and shall be subject to acceptance by Urban Utilities
- Orifice size, flange size, flange rating and instrument number shall be stamped on the upstream side of each orifice plate and shall be visible when the orifice plate is installed

Orifice plate flow meter flanges shall have the following requirements:

- Flanges shall be in accordance with ASME B16.36
- Flanges shall be weld neck type
- Pressure taps shall be equipped with round head or stock plugs
- Flange rating, facing and finish shall be as per the piping specification, or ASME Class 300 minimum, whatever is greater
- Flange tapping arrangement shall be utilised for all orifice plate installations

Differential pressure (DP) transmitters shall be remote mounted to minimise or eliminate vibration issues and lengths of impulse piping should be kept to a minimum.

The following guidelines shall be used to determine limitations for direct mounting of transmitters:

- DP transmitters shall be direct mounted in lagged service up to process temperature of 250°C
- DP transmitters installed on process temperatures above 250°C shall require remote seals of fill fluids suitable for such temperatures
- DP transmitters shall be direct mounted in flushed services where the fluid is within the transmitter temperature limits
- For installations in vertical pipelines the direction of flow shall be downwards for wet gases or saturated steam and upwards for liquids
- Upstream straight length requirements shall be in accordance with AS 2360
- DP transmitters in gas service shall be mounted above the flow element
- DP transmitters in liquid service shall be mounted below the flow element
- DP transmitters for use in flow applications shall have a five-valve manifold

4.12.4.3 Magnetic Flowmeters

Magnetic flowmeters may be used in water and sewage services. Magnetic flow meter excitation shall not exceed 24 VDC. The flow transmitter shall be mounted remotely in a suitable electrical enclosure and not integral to the meter body. An earthing ring with protecting edge shall be supplied and installed as per the flowmeter manufacturer's

recommendations. The electrodes shall be fixed type. The electrode material of construction shall be 316 SS, unless other material is required for corrosion resistance.

4.12.4.4 Other Flowmeters

Ultrasonic flowmeters are the preferred measurement technique for flow measurement. Alternatives to ultrasonic flow meters shall be subject to the acceptance of Urban Utilities.

Averaging pitot tubes or thermal dispersion meters may be used in special applications, subject to Urban Utilities acceptance. Installation of averaging pitot tubes shall be such that they are removable online, unless indicated otherwise.

Inline variable area flow meters shall only be used on non-critical processes and these shall have 316 SS bodies with magnetic followers (unless other material is required for corrosion resistance). The use of glass tube type shall be subject to the acceptance of Urban Utilities. In-line variable area flow meters shall be installed in the vertical position.

Positive displacement flowmeters may be used for local flow indication/totalising in non-critical process lines.

4.12.4.5 Mass Flow

Coriolis type mass flowmeters are preferred for liquid mass flow applications. Straight tube type Coriolis mass flowmeters are preferred over bent tube type.

4.12.5 Level

Where more than one level transmitter is required on a vessel, both shall be calibrated to the same operating span and level wherever possible. Where level gauges (magnetic or glass) are installed alongside other level instrumentation the level gauge span shall match or exceed that of the vessel operating range. Where vessels have both level instruments in control and shutdown applications, different types of level transmitters shall be installed to reduce common mode failures.

For continuous level measurement, the following level transmitter types are the preferred choice:

- Magnetic follower style gauges with magneto-restrictive level transmitters for use in shutdown applications
- Hydrostatic pressure
- Ultrasonic
- Capacitance
- Conductive liquid
- Guided wave radar

Use of capillary filled DP transmitters with diaphragm seals may be considered subject to Urban Utilities' acceptance. The lower connection point to a vessel shall not be taken from the bottom of the vessel to minimise fouling of tappings and ensure full range of measurement. Where bottom of vessel nozzle connections cannot be avoided, an upstand in the vessel should be installed.

Level instruments shall be located such that they are visible and accessible for calibration, maintenance, or repair from grade or from a permanent platform.

Continuous level measurement instruments shall be provided with a means of in-situ range checking and testing.

On liquid/liquid interface service the vessel top instrument connection shall be submerged in the lower density fluid under all normal operating conditions. Level in vessels and equipment shall be displayed in terms of 0-100% working range unless specified otherwise by Urban Utilities. Operating range must be less than the working range capacity of the vessel.

Any special applications for a level switch (e.g. sump pump auto-start/stop) shall be accepted by Urban Utilities.

4.12.5.1 Guided Wave Radar

Radar level measurement shall only be considered where the relative dielectric constant of the measured medium is suitable for this technology and other level measurements are considered unsuitable for the application. Radar transmitters shall be installed in a manner that allows the instrument removal online without impact on the process.

Installation of radar elements shall meet manufacturer criteria for clearance from sidewalls and internal obstructions.

4.12.5.2 Level Bridles

Level bridles shall be utilised to minimise the connections on a vessel and to facilitate instrument testing. Sufficient block, vent, and drain valves shall be installed to permit in-place testing of instruments without the need to shut down the process.

Where several level instruments are required on a vessel, a separate bridle shall be used by each level instrument.

Bridle process interfaces shall be via DN50 flanges having a minimum rating of ASME class 300. Level bridle material of construction shall be 316 SS unless another material is required for corrosion resistance. Bridles shall be equipped with DN20 (minimum) vent and drain valves.

No Bridles shall not connect across more than two adjacent phases on a three-phase vessel. In this event, a third balancing connection is required to accommodate the middle phase.

Careful consideration must be given to the placement of the taps in relation to the normal location and range of the interface. In some cases, additional taps may be required to ensure continuous and correct measurement of the interface. No Vertical doglegs shall are permitted in making level connections to bridles.

Bridles shall not be used under the following circumstances:

- In service at low temperature (<0 °C)
- In viscous service and in applications where process fluids contain high concentrations of solids

Level bridles and gauges shall be supplied with vent and drain valves.

4.12.5.3 Differential Pressure (DP) Level

Response times and temperature effects shall be calculated (as % of span) for each remote seal application by the instrument supplier, over the range of process and ambient temperatures for the application. In particular, the effects on accuracy shall be reviewed for the case when the top seal temperature increases suddenly as the hot process liquid rises. Where the effects on accuracy are unacceptable alternative measurement techniques shall be provided.

4.12.5.4 Level Gauge Glasses

Excess flow type isolation cocks shall be fitted as standard Reflex type gauges are only suitable for clean liquid services. Transparent sight glasses shall be used for other services. Vertical doglegs shall be are not permitted in making level connections to gauge glasses.

Gauge glass shall be of such quality that it shall break with an interlocking crystalline fracture without loose, flying particles (normally referred to as tempered glass).

Gauge glasses shall be equipped with DN20 vent and drain valves. Drain valves shall be piped into the facility drain system.

4.12.5.5 Nuclear Level

Nuclear type level measurement shall be used only when other methods cannot provide the required accuracy or reliability. The use of this type of measurement requires Urban Utilities' acceptance.

Compliance with the statutory and site requirements for handling radioactive devices shall be ensured at all times. All specific design documentation and regulatory

approvals shall be provided. The operations and maintenance requirements of the instrument must be accepted by Urban Utilities.

4.12.6 Pressure

4.12.6.1 General

Pressure elements shall be specified such that the steady normal operating pressure does not exceed 75% of the maximum range.

Pressure elements shall be such that the process pressure does not exceed the maximum rating of the element. If the process pressure can exceed the instrument rating pressure then an adequate overpressure protection technique shall be provided. For each application, Urban Utilities shall accept the technique proposed to be implemented.

Pressure sensor material of construction shall be 316 SS unless another material is required for corrosion resistance. Pressure instrument process connections shall be ½" BSP.

In corrosive services where a direct mounted pressure element is not appropriate, a diaphragm seal shall be used. Where the pressure element will be subjected to pulsating pressures (e.g. inlets and outlets) the following steps are to be taken:

- Element shall be specified such that normal operating pressure does not exceed 60% of maximum range.
- A pulsation damper shall be used. Dampers shall be of the non-adjustable type.

A method to depressurise the process line or vessel to gain access to disconnect the instrument shall be provided.

4.12.6.2 Pressure Gauges

Pressure gauges shall comply with AS1349 and have the following features:

- ½ " BSP bottom entry
- 316 SS movement
- Oil filled housing
- 100 (or 115) mm diameter dial
- Weatherproof 316 SS (IP65 rating or better)
- Solid front
- Shatter proof glass
- Blow out back (or pressure relief vent for the cases)
- White dial with black lettering and black pointer
- Isolation valve

Pressure gauge measuring elements shall be the C-type or helical Bourdon type. The measuring element shall be 316 SS, unless process fluid requires the use of other materials.

Pressure gauges shall be selected so that the normal operating pressure is 50-70% of the full range of the gauge. Pressure gauges shall be able to withstand over-ranging to a pressure of 1.3 times the maximum scale reading without a permanent set that affects gauge calibration. In moderate vibration service (e.g. centrifugal pump suction), the gauges are to be liquid filled with glycerine or equivalent.

4.12.7 Temperature

Temperature instruments (dial thermometers, thermocouples and RTDs) shall be installed in flanged thermowells. Exceptions (e.g. skin temperatures) may be proposed for Urban Utilities review. Temperature instruments shall be ranged to include start-up and abnormal operating conditions unless otherwise specified by Urban Utilities.

4.12.7.1 Dial Thermometers

Field temperature indicators (dial thermometers) shall be of the bimetallic type, with a 125 mm dial size unless otherwise specified. Dial thermometers shall have adjustable every-angle heads. The element diameter is nominally 6mm with a ½" BSP connection.

In applications where bi-metallic thermometers are not suitable, filled systems may be used. The preferred materials for filled systems are 316 SS wetted parts with gas fill. All such applications are to be accepted by Urban Utilities.

Where required for readability or protection from vibration, indicators shall utilise a fully compensated filled system with a 316 SS armoured capillary tube and with a remote reading dial.

Mercury thermometers shall not be used. Where possible, dial thermometers shall comply with the manufacturer's standard ranges.

4.12.8 Temperature Elements and Transmitters

Dual sensor 3-wire Pt100 RTDs are the preferred option. 4-wire RTDs may be used where required. The use of 2-wire RTDs requires acceptance by Urban Utilities. Where RTDs are not suitable, i.e. due to required measuring range, Type K thermocouples can be used.

Where process temperatures allow, elements shall be direct connected to the temperature transmitter. Where remote indication is required a loop-powered indicator shall be installed.

RTDs shall have 6mm OD, 316 SS sheaths. Sensors shall feature spring loaded heads in their assemblies.

Thermocouples shall be mineral insulated metal sheathed (MIMS). These thermocouples shall be 6 mm OD with insulated junctions and 316 SS sheathed. Thermocouple terminal heads shall be spring loaded.

When Vendor packages include the supply of tube skin thermocouples (e.g. fired heaters) the thermocouples shall be installed with thermocouple heads to allow remote mounting of temperature transmitters. Where tube skin thermocouples during plant shutdown.

Use of high temperature rated cable shall be considered if thermocouple extension and RTD cables are run close to hot surfaces.

4.12.9 Analysers

The design and selection of analysers is viewed as warranting special consideration. All proposed analysers, including sampling handling systems must be accepted by Urban Utilities.

Unless the actual analyser model number is currently proven on Urban Utilities sites, no analyser or sampling handling and recovery system shall be introduced to Urban Utilities site without it first complying with a guaranteed Performance Test; in agreement with Urban Utilities and the equipment Supplier. The Performance Test shall be carried out on site by the analyser supplier, or their nominated agents, and this shall be included when undertaking analyser supply.

If the initial Performance Test fails, all modifications and subsequent Performance Test shall be undertaken by the analyser Supplier at no additional cost to Urban Utilities. Lab sample points shall be provided on all analysers. Auto changeover manifolds to be provided on carrier gases. Low carrier gas pressure shall be alarmed to SCADA. Low sample flows shall also be alarmed to the SCADA.

In general, analyser outputs shall be 2 wire 4-20 mA loops. Where an analyser reports multiple analyses the use of a communication link shall be provided. Refer TMS1733 *Control Systems General Specification* for acceptable communication protocols. Common hardware alarms for each analyser shall be provided and alarmed to the site SCADA.

Liquid samples shall be returned to process. Only where accepted by Urban Utilities shall biogas be vented to site flares or the atmosphere.

Analysers shall be mounted as close as practical to the sample point in a weatherproof naturally vented shelter or prefabricated enclosure subject to acceptance by Urban Utilities. Local flow, pressure and temperature indications shall be provided on analyser sample handling systems. Analysers shall have power isolators mounted adjacent to each analyser in the field.

The analyser shall have a local shutdown and start-up facility, allowing the operator to take the analyser out of service during unit upsets etc.

Where product sampling is required the sampling shall be continuous and independent of the main process.

4.12.10 Instrumentation and Control Cables

4.12.10.1 General

High Frequency pulse signals shall be transmitted via a dedicated cable wired direct from the field device to the end device e.g. flow computer. Intermediate cable breaks, i.e. wiring via junction boxes, shall be avoided to maintain signal integrity.

4.12.10.2 Process Control Network Cabling

Refer to TMS1733 *Control Systems General Specification*.

4.13 Packaged Plant Equipment

Equipment packages may include, but not limited to the following skid mounted equipment:

- Blower skids
- Centrifuge skids
- Multi Pump Manifold Pump Skids
- Waste Gas Burners (enclosed flares)
- Air Compressors
- Instrument Air Driers

Low voltage motor starters, instrumentation and proprietary control systems needed for the systems are generally supplied as part of the packaged equipment.

Refer to TMS1645 *Package Plant EI&C* for specific design requirements.

4.14 Lighting

4.14.1 General

Light fittings may be selected from those listed in TMS62 *Preferred Electrical and Instrumentation Equipment List*. The use of other light fittings is subject to Urban Utilities' approval.

Light fittings shall be LED.

4.14.2 Gate Approach Lighting

At RRC sites and other permanently manned sites a pole mounted LED light at the maintenance gate entrance shall be operated by motion sensor activated by an approaching vehicle. An outdoor rated Automatic / Manual lighting selector switch box

shall be installed at the gate post with local control switches to plant general area lighting and maintenance lighting circuits.

4.14.3 Plant Area Lighting

Plant area lighting circuits shall be controlled by contactors located at lighting distribution boards as appropriate. External lights shall be able to be switched ON/OFF using the site control system either in total or by plant area.

External lighting shall automatically switch off in daylight hours via a day/night switch, with an override facility for testing purposes.

External lighting shall include manual direct switching facilities adjacent to the relevant local light and power distribution board.

Light poles shall not be fixed to handrails except by approval. The basis of approval will be RPEQ-endorsed structural calculations demonstrating the continued structural performance of the handrails following installation of the light poles.

Light poles shall meet the requirements of AS 1170 when subjected to the site service conditions.

Light poles greater than 1.8 metres in height (e.g. walkways, outdoor work areas and general plant areas) shall be designed such that maintenance of light fittings may be carried out from the ground or walkways without the use of an elevated platform workstation or ladders (e.g. fold-down poles).

Lighting columns shall be of the lowering type and shall not require an elevated platform to access the light fittings. The lowering apparatus shall be operable from outside the fall zone. Any control gear associated with lighting poles shall be mounted at the base of the pole so that it is accessible from the ground for maintenance. Control equipment shall have a dedicated CBs provided at the base of the pole for local isolation. Poles supporting multiple luminaires shall have an individual protective device per luminaire located at base of the pole.

4.14.4 Emergency Lighting

Emergency lighting systems shall employ standalone single two-hour battery backed maintained luminaires. UPS-backed emergency lighting circuits are not accepted.

Manual testing facilities complying to AS 2293 shall be provided at lighting distribution boards where required.

4.15 Fire Detection Systems

Wiring between each component of the fire detection system shall be rated to WS5XW (2-hour fire resistance, resistant to water spray) as defined in AS 3013 and segregated from all other wiring.

Fire suppression systems are not required. Facilities shall be provided at the FIP for Emergency Warning System functions. An I/O interface card shall be provided in the FIP to connect to the site PLC control system.

A battery backup power supply housed within the FIP shall be provided for the fire detection system. The battery shall be rated to provide maximum demand of all connected equipment to the FIP such as smoke detectors, MCPs etc. A maximum demand calculation shall be provided to determine battery size required.

Two spare unused volt free fire alarm contacts in the FIP shall be provided for interfacing other signals to the site control system in future.

Switchrooms shall be provided with at least two off smoke detectors, actual number and location shall be indicated on the Project Drawings. Status and alarms shall be configured to SCADA and at the local HMI in the switchroom.

The condition for a confirmed fire in the switchroom is when any one of the following occur

- MCP is activated
- VESDA system detects smoke and one smoke detector is activated

On confirmed fire detected in the switchroom the fire systems shall:

- Shut down HVAC units where required to comply with the National Construction Code
- Activate a local strobe light mounted external above the switchroom access doors
- Activate a local siren
- Activate PAGA speakers through PLC/ SCADA interface

Refer TMS1188 *Demountable Switchroom* for fire detection systems in demountable switch rooms.

4.15.1 Aspirated Smoke Detection Systems

Aspirated smoke detection systems shall consist of a highly sensitive laser-based smoke detector complete with an aspirating fan and filter connected to a network of pipe and sampling points and detector displays (e.g. VESDA). The system shall only sample air within the switchroom, cable basements/trenches and not within switchboards or other enclosures.

The system shall be modular in design and the detector shall be monitored by a display dedicated to a specific detector to show a visual representation of smoke levels detected by a particular detector.

The system shall be of a type designed, manufactured and tested to comply with AS 7240.20. The detector shall be provided with LED indicators.

Each detector shall provide the following features at a minimum:

- Independent high intensity alarm indicators for Pre-Alarm and Fire (Alert indicated by the Pre-Alarm LED flashing) corresponding to the alarm thresholds of the detector:
  - Fault indicator
  - OK indicator
- Isolate indicator
- Controls supporting the following features:
  - Reset – Unlatches all latched alarm conditions
  - Isolate – Isolate (inhibits Alarm and Fault relays and initiates the Fault relay)
  - The unit shall be equipped with configurable relays for signalling alarm and fault conditions. Initial settings for the alarm levels shall be determined by the requirements of the fire zone.
- Default settings of the unit shall be:
  - Alarm Level 1 (Alert) 0.08%/m with a delay of 10 seconds
  - Alarm Level 2 (Pre-Alarm) 0.14%/m with a delay of 10 seconds
  - Alarm Level 3 (Fire) 0.2%/m with a delay of 10 seconds

The detector fault relay shall be connected to the addressable interface device located in the FIP in such a way that a detector fault would register a fault condition on the FIP.

The fault relay shall also be connected to the appropriate control system.

The system shall be powered from regulated 24V DC supply from the FIP.

The response time for the least favourable sampling point in the system shall not exceed 90 seconds.

Refer TMS1188 *Demountable Switchroom* for aspirated smoke detection system requirements in demountable switchrooms.

4.16 General Power

4.16.1 Socket Outlets

Standard installation drawings shall detail the typical installation arrangements for power outlets and switches in the plant. Each outlet and switch shall be assigned a tag number indicating its source distribution board and circuit breaker. The outlet tag number shall be correlated with the associated circuit breaker number on the distribution board legend.

Socket outlets shall be selected as follows:

Application	Minimum Rating	Description	Special Conditions
Non-industrial areas (offices, control rooms etc.)	10A 1ϕ	Moulded plastic, flush mounting, general purpose outlet	Essential or UPS supplied outlets shall be coloured red and labelled “UPS Supply - Not for General Use”. Other GPOs shall be coloured white.
Outdoor industrial areas	15A 1ϕ	Heavy duty industrial grade UV & corrosion resistant Minimum IP65 IP rating Has an auto-closing flap	
Motors	20A 3ϕ+N		
Welding outlet	63A 3ϕ+N+E		Earth leakage protection (selectable up to 250mA) shall be provided
Other three-phase applications	20A 3ϕ+N+E		

Circuits for socket outlets rated at 32A or less shall be protected by a separate circuit breaker with 30mA RCD at the point of supply.

External socket outlets near hazardous areas shall be installed in minimal quantities to avoid hazards associated with unauthorised hot works. Socket outlets shall not be installed within hazardous areas.

Refer to Section 5.8.5 Power Outlets and Switches for installation requirements.

4.16.2 Distribution Boards

Project Documentation shall define the circuit configurations for all light and small power distribution boards including control and switching functionality for all loads.

LV lighting and small power electrical loads shall be balanced across all three (3) phases.

Any additional lighting and small power loads not defined in Project Documentation that are to be supplied from distribution boards shall be circuited in a configuration consistent with that used for the other documented loads on the distribution board. The circuit arrangements for any such additional loads shall be accepted by Urban Utilities prior to commencing the installation works.

Refer to TMS60 *LV Switchboards* for detailed requirements.

4.17 Switchroom HVAC Systems

HVAC units shall be inverter type and units in excess of 8kW rated electrical load shall have 3ph, 400V AC 50Hz supply.

On general power failure to the switchroom all HVAC units shall restart automatically without operator intervention, when power is re-established to the building. HVAC units are not considered an essential load and shall be fed from the general power and lighting switchboard in the switchroom.

On a confirmed fire (i.e. when conventional detectors detect fire), HVAC units that circulate air between rooms shall shut down immediately. Split-system air conditioners recirculating air within a single room need not shut down. A voltage free contact shall be wired direct from the FIP to the distribution board containing the HVAC unit power supply contactors.

HVAC units shall be individually monitored by the control system. Voltage free contacts shall be provided for HVAC Running and separate input for HVAC General Fault. The signals shall be wired to the local PLC control panel for alarms to be provided at SCADA.

HVAC units shall be provided with their own inbuilt temperature controllers. A battery powered portable remote controller for each unit shall be wall mounted near the switchroom personnel access door. A fixed hardwired wall mounted controller panel in the switchroom is also accepted.

Switchrooms shall be provided with a wall mounted temperature sensor to provide an analogue 4-20mA temperature signal to the local PLC. The room temperature shall be displayed at SCADA and warning alarms produced if temperature exceeds 30°C.

Refer to Section 5.3.3 Switchroom Air Conditioning for further information regarding the installation of HVAC units.

Refer TMS1188 *Demountable Switchrooms* for HVAC requirements in demountable switchrooms. The HVAC design report and switchroom HVAC layout drawings must be accepted by Urban Utilities before commencing the demountable switchroom manufacture.

5 INSTALLATION

5.1 General Requirements

5.1.1 Personal Protective Equipment

All workers performing electrical work shall perform a risk assessment to determine appropriate PPE for the task with minimum requirements as set out in AS/NZS4836 and WI58 Arc Flash Hazard Assessment and PPE Selection.

5.1.2 Urban Utilities' Site Induction Training

All personnel shall attend a Site Induction Training course prior to being granted site access by Urban Utilities.

Attendance at Site Induction Training will require prior evidence of certification in relation to Lock-out/Tag-out (LOTO) training.

5.1.2.1 Lock-Out/Tag-Out (LOTO)

PRO379 Energy Lock Out Tag Out Procedure applies to all personnel on Urban Utilities controlled workplaces. This procedure applies unless a Contract detailing control of a workplace has nominated a principal contractor other than Urban Utilities.

Personnel performing electrical work shall undergo Lock-out/ Tag-out (LOTO) training and satisfy the requirements of this training prior to obtaining access to Urban Utilities live electrical equipment. Evidence of satisfactory completion of the training shall be provided to Urban Utilities before undertaking the Urban Utilities' Site Induction Training.

5.1.3 Workmanship and Personnel

Personnel engaged in the construction of electrical installations shall be accredited, suitably experienced, competent and skilled in the field of work in which they are engaged. All 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 Electrical Safety Regulation.

Personnel engaged in the construction of electrical installations in hazardous areas shall be accredited, suitably experienced and assessed as competent in accordance with AS/NZS 60079.14 and AS/NZS 4761 or an equivalent training and assessment framework.

Persons employed on the works shall be directed by experienced qualified supervisors who shall be responsible for the works and for ensuring that personnel under supervision are conversant with and comply with Urban Utilities' Safety Rules and Regulations, particularly those rules controlling the use of work permits.

Urban Utilities 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, of unacceptable quality or commensurate with acceptable trade practice.

5.1.4 Rectification of Existing Installations

Electrical equipment and installation shall be controlled and quality assured as electrically safe in accordance with AS/NZS 3000 and the Queensland Electrical Safety Act.

If out of scope equipment, circuits or electrical installations that cannot be safely energised or are otherwise electrically unsafe are discovered, Urban Utilities shall be notified and given a detailed description of the issue along with a proposed solution. Direction shall be sought from Urban Utilities.

5.1.5 Use of Correct Tools

Equipment and tools to be utilised in the electrical installation 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. Tools and equipment shall be used in accordance with the manufacturers' instructions when available.

Tools and appliances furnished with installed equipment shall be maintained in good condition and handed over to Urban Utilities on completion of the works.

5.1.6 Mounting for Ergonomics

No items of equipment intended to be operated or viewed by an operator (pushbuttons, switches and meters) shall be mounted between 400mm and 1900 mm above floor level. Field instruments shall between 700mm and 1600mm from the floor or platform level.

Refer to the communication and control panel requirements of TMS1733 *Control Systems General Specification* for requirements regarding mounting equipment within new or existing control panels.

Refer to TMS60 *Low Voltage Switchboards* for requirements regarding the mounting of equipment within new or existing LV switchboards and distribution boards.

Due consideration shall be given to the following:

- Visibility and accessibility for both maintenance and operations purposes. It shall not be necessary to open any door or remove any cover to operate or reset equipment that is required for normal operation
- Equipment and devices shall be installed in such a manner that all necessary electrical clearances are observed and that the rating accuracy of devices is not impaired either thermally or electromagnetically by the proximity of other equipment, devices or cables.

- No piece of equipment shall be mounted behind other equipment or in any manner denying free access for removal or maintenance. Care shall be taken to ensure ease of access for lifting heavy items such as valves
- Positioning of equipment does not constitute a safety hazard
- Equipment does not conflict with any existing or proposed underground services
- Enclosure opening door swing shall not obstruct escape routes, walkways or access to plant or equipment

The following requirements for instrument mounting shall apply:

- Instruments and valves should be free from vibration with the exception of those specifically designed for vibration measurement
- Instruments shall be installed in an upright position as close as practical to the process that it is servicing
- Instruments shall be fitted such that a single person can remove them, where size and weight permits

5.1.7 Mounting Stands

Mounting stands, brackets, stanchions and stand mounting plates shall be hot dipped galvanised (preferred) or painted as per Section 5.1.15 Coatings. Stand assemblies shall be all welded construction. Weld gas vents, galvanising vents and drain holes shall be provided in the lowest part of the stand. Bolt holes shall be drilled prior to coating as per Section 5.1.10 Cutting, Drilling and Welding.

Where stands are to be bolted to concrete footings a gap of at least 20mm shall be created to allow levelling. The gap shall be filled with grout and finished neatly. Where the stand is mounted on steel plate or grid flooring, it shall be levelled by shimming and then welded or bolted in place. Bolting to grating is not accepted.

5.1.8 Mounting Brackets and Supports

Project Documentation will include standard bracket and support arrangements for the installation of electrical equipment. All brackets and supports to be procured or fabricated shall be in accordance with the materials and arrangements specified in these documents unless otherwise accepted by Urban Utilities. For any brackets and supports that are not defined in these documents, a proposed arrangement shall be designed and submitted to Urban Utilities for acceptance. No Procurement, fabrication or installation shall proceed without the receipt of acceptance from Urban Utilities.

Brackets and supports to be fixed to the plant steel structure shall be welded to the steelwork, clamped or bolted through holes punched or drilled in the steelwork. Clamped brackets and supports must be of a proprietary manufactured type, rated for the application and must not cause damage to structures or protective coatings. Where required, additional measures (e.g. hygroscopic spacer plates) shall be taken to spread the mechanical load at the point of contact and prevent the creation of galvanic circuits.

Under no circumstances shall any welding or fixing operations be carried out on any process plant equipment, vessels, pipelines or structures. Fixings to the above shall normally be made with purpose-designed brackets provided by the plant supplier.

All mounting plates shall have sufficient space for fitting of equipment nameplates. Large equipment mounting panels, exceeding 1000 mm in any direction, shall be secured by a minimum of six welded studs and nuts.

Mounting brackets shall not be fixed to plant or steelwork that will be subject to excessive vibration during plant operation.

5.1.9 Fasteners and Fixings

Fasteners and fixings shall generally be zinc or cadmium plated for indoors and either hot dip galvanised steel or 316 stainless steel for outdoors. For sewage treatment plants, only 316 stainless steel shall be used for both indoors and outdoors.

Care shall be taken to select suitable materials for fixings installed in corrosive environments.

Care shall be taken to avoid galvanic corrosion issues caused by contact between dissimilar metals via appropriate material selection, the use of insulating washers, nylon/plastic sleeves or other methods.

All bolts, nuts, and stud screw threads shall be ISO metric threaded.

Application	Accepted Fixing Methods
Masonry	Screws with plastic or metal fibre expansion plugs[1] Expansion bolts
Concrete	Screws with plastic or metal fibre expansion plugs[1] Expansion bolts[2] Grouted hold-down bolts Chemical Anchors
Timber	Screws Bolts
Metal	Screws Bolts Welding Proprietary clamps

Notes:

1. Plastic or metal fibre expansion plugs shall only be used for low-weight fixings (e.g. conduit saddles for lighting). When used in office buildings, these shall be in line with quality commercial installation practices. When used elsewhere, fixings of this type shall allow for later removal (e.g. plastic star plugs with stainless steel screws). Nylon mushroom anchors and other nail-in or non-removeable expansion plug products are not permitted in outdoor areas.

2. Expansion bolts require prior approval by Urban Utilities

5.1.10 Cutting, Drilling and Welding

Surfaces altered via cutting, drilling or chasing shall be restored to the original finish after completion of the works. The structural integrity of concrete, steel and timber structures shall be maintained and ensure no contact between dissimilar metals.

Where possible holes shall be drilled, not cut with a flame, and drilling shall be made with minimum tolerances.

Sharp edges shall be de-burred.

Hot dip galvanised steel items shall not be fabricated or modified on site. All welded, cut or drilled hot dip galvanised steel shall have the exposed metal cleaned, painted with zinc enriched cold galvanising paint. Pre-drilled hole sizes shall allow for the zinc coating thickness. Aerosol spraying is not an acceptable method of applying galvanising paint.

Structural steelwork shall not be cut, drilled or welded without approval from Urban Utilities.

Pre-cast concrete slabs or tilt-up panels shall not be cut or drilled without approval from Urban Utilities. Exposed reinforcement structural steel in concrete slabs shall be sealed with an accepted rust prevention coating system.

Welds shall comply with the appropriate welding code and shall be primed and painted on completion. All stainless steel welds shall be pacified to prevent corrosion.

Penetrations for the purpose of cables, conduits or cable ladder entries shall be installed using proprietary and purpose made jigsaws and drills. Penetrations shall be fitted with kick plates and/or flashings to provide a neat finish.

5.1.11 Sealing Penetrations and Conduits

Building penetrations shall be sealed after completion of the installation to:

- Match surface finishes
- Maintain Ingress Protection rating (as required)
- Prevent vermin entry
- Maintain fire rating (as required) with an accepted fire sealant compound
- Comply with the requirements of hazardous area classifications (as required)
- Meet National Construction Code Regulations

Sealing Application	Approved Methods	Prohibited Methods
Wall & non-concrete floor penetrations	Cement grout, non-expanding mastic (i.e. a permanently plastic waterproof compound), concentric ring-type pressure seals, sealed packing bags	Expanding foam, silicone
Concrete floor penetrations	Cement grout	All other methods

Sealing Application	Approved Methods	Prohibited Methods
Buried conduits exiting the ground (all, including spare)	Non-expanding mastic (i.e. a permanently plastic waterproof compound)	Expanding foam, silicone
Outdoor surface-run conduits (both ends)	Heat shrink tubing, suitable sealing compounds as accepted by Urban Utilities	All other methods

After the installation of cables, all buried cable conduits exiting the ground shall be sealed to prevent the ingress of water or oil. A waterproof seal shall be provided by the application of a permanently plastic waterproof compound. All spare conduits shall be similarly sealed. The sealing compound shall be capable of being removed to enable additional cables to be installed if required at a later date.

After the installation of cables, all outdoor surface conduits shall have both ends sealed using heat shrink tubing or a suitable sealing compound as accepted by Urban Utilities. Cement grout shall meet the requirements of TMS 1439 *Civil & Structural General Specification*. Sealing methods other than cement grout shall be of a non-setting, durable, weatherproof type that is suitable for later removal.

Penetrations in areas with a hazardous area classification shall be in accordance with Section 5.13.2 Wiring and Conduit Systems, shall be accepted by Urban Utilities and shall be suitably certified as required and in accordance with the Manufacturer's specifications.

5.1.12 Setting Out Works

Project Documentation will include installation locations for electrical equipment. For instances where the exact location is not clearly defined in Project Documentation the area shall be assessed via a site visit.

Following this assessment, a proposed exact installation location shall be submitted to Urban Utilities 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, chemical lines etc)
- Electrical clearances
- Induced voltages

- Hazardous areas
- Thermal loads and ventilation
- The design intent of Project Documentation

5.1.13 Erection

Electrical equipment shall be installed strictly in accordance with the Supplier's instructions and the relevant Project Documentation. Where such instructions are not available, details of the proposed installation method shall be accepted by Urban Utilities before commencing the works.

Plant of significant weight or size shall be installed by suitably qualified personnel utilising specialised plant (cranes etc). For all such installations a customised lifting study shall be completed. This lifting study shall be accepted by Urban Utilities prior to commencement of the works.

5.1.14 Foundations and Concrete Structures

Items to be cast into the concrete (i.e. rag bolts, conduits, earthing connections etc) shall be correctly positioned for alignment prior to pouring of concrete. All items to be cast into the concrete shall be adequately fixed to the reinforcement steel or formwork to ensure they are not disturbed during the concrete pour. Any items to be cast into the concrete that have critical tolerances (<±50mm) shall be surveyed prior to the concrete pour.

Refer to TMS1439 *Civil & Structural General Specification* for details regarding concrete structures.

5.1.15 Coatings

5.1.15.1 Painting

Where required, Project Documentation shall nominate an appropriate painting system considering location, weather, pollution and corrosive environments. Where not nominated in Project Documentation, painting systems shall conform to the requirements of WSA 201 *Manual for Selection and Application of Protective Coatings and* TMS76 Corrosion Protection Supplement to the WSA 201

Where an alternative painting system is proposed, the following details shall be provided:

- The surface preparation, paint process, paint type and thickness
- A description of how the alternative paint system is equal to or superior to the specified requirements

The proposed alternative surface protection treatment will be evaluated by Urban Utilities for acceptability, provided the above details are provided.

5.1.15.2 Hot Dip Galvanising

Hot dip galvanised items shall, as a minimum, comply with the requirements of AS/NZS 4680 and provide the corrosion protection required to achieve the design life specified in Section 3.4.2.

Minor damage to galvanised materials shall be made good by touch-up using zinc enriched cold galvanising paint. Thickness of paint shall be appropriate for the environmental conditions.

5.1.16 Care and Maintenance

All site personnel shall be fully aware of and comply with the requirements for good housekeeping on the site. Necessary tools and equipment shall be managed to ensure a safe working environment for the works. Work areas shall be kept free of rubbish.

Rubbish in switchrooms and similar areas shall be collected and disposed of daily in accordance with the accepted site procedure. Only those materials and equipment required for immediate use shall be stored in these areas.

Flammable debris shall be removed prior to working with naked flame tools, welding, cutting or grinding equipment. Equipment shall be protected from damage by grinding, drilling, swarf, grit blasting etc. 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. Care shall be taken when cutting and removing armour on braided cables within switchgear enclosures.

Equipment not being actively worked on shall have all doors closed with 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 equipment or switchboard cubicles.

After terminating cables, the equipment/enclosure shall have dust and rubbish cleaned out using suction cleaners. The equipment shall be inspected for internal moisture and dried-out prior to energisation. HV equipment and insulators shall be wiped down with a lint free cloth to remove dust.

Prior to the removal of access equipment (scaffolding, EWPs etc.),elevated cable pathways shall be inspected to ensure cable pulling equipment and debris are removed, cable covers are properly installed and equipotential earths applied.

5.1.17 Temporary Power Installations

Power distribution systems installed for the express purpose of providing temporary power for construction works shall be rugged and suitable for the required duty. These systems shall be designed and tested to relevant Australian Standards, including AS/NZS 3012 *Electrical installations – construction and demolitions sites*.

5.1.18 Galvanic Corrosion

Suitable measures accepted by Urban Utilities shall be adopted to minimise the effects of electrolytic corrosion such as:

- Use of stand-off washers when mounting equipment of dissimilar metals onto structures
- Coatings of proprietary compounds, specially manufactured for the purpose, when mounting equipment of dissimilar metals onto structure
- Use of bi-metallic lugs for the termination of conductors of dissimilar material onto switchgear or similar
- Segregation of dissimilar metals during lay-down and storage

Site works shall ensure the integrity of the Cathodic Protection system (where installed) is not compromised.

5.1.19 Environmental Obligations

Works shall be in accordance with the accepted Environmental Management Plan (EMP).

EMPs shall be in accordance with the objectives and requirements of the project environmental conditions of approval.

The EMP shall provide detailed information on how the site works will be managed to ensure that they are undertaken in an environmentally responsible manner, in accordance with all regulatory/project specific environmental requirements. Environmental controls should be specified for issues such as the management of soils; trenching and backfilling; erosion and sedimentation; watercourse crossings; and waste management.

In addition, the requirements of relevant accepted environmental plans shall be considered when developing the EMP, including (but not limited to):

- The Soil Management Plan
- The Remediation, Rehabilitation, Recovery and Monitoring Plan

5.2 Materials and Equipment

5.2.1 Supply

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

For all non-specified equipment, TMS62 *Preferred Equipment List – Electrical* and TMS1151 *Preferred Equipment List – Control Systems* shall nominate the preferred suppliers and/or equipment. These requirements shall not be deviated from without prior written approval from Urban Utilities. Where the materials are not specified, standard materials suitable for the application, environment and operating/design conditions may be offered. Non-specified equipment shall be of the same type, grade

and quality as similar items specified in Project Documentation. Corresponding parts of similar equipment shall, where possible, be interchangeable.

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

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

All materials shall be free from:

- Refractory Ceramic Fibre or High Biopersistence Fibre
- Radioactive materials
- Mercury

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

5.2.2 Handling, Storage & Preservation

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

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

The safety, security and preservation of equipment and materials received shall be maintained for the duration of the Works. Equipment and materials shall be stored in a suitable location and environment appropriate for the duration of storage in accordance with the Supplier's recommendations to prevent any damage, deterioration or corrosion prior to installation (e.g. covering PVC conduit with tarps to prevent UV degradation). Preservation schedule shall be as per manufacturer recommendations.

Where required, temporary power supplies shall be provided to equipment for preservation (e.g. anti-condensation heaters, air conditioning in demountable switchrooms).

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

5.2.3 Surplus and Scrap Materials

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

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

Waste materials shall be disposed of in accordance with the accepted EMP.

5.3 Equipment Installation and Decommissioning

5.3.1 General

Materials and installation arrangements shall be in accordance with the standard installation documentation unless otherwise accepted by Urban Utilities. For equipment or installations that have not been defined in these documents, a proposed arrangement (as per section 3.1.3 Design Activities) shall be designed and submitted to Urban Utilities for approval. No Procurement, fabrication or installation shall commence without the receipt of approval from Urban Utilities.

Suppliers' installation recommendations shall be made available and reviewed prior to the commencement of any installation works. All supplier installation recommendations shall be strictly followed. Any conflict between the standard installation documentation and the supplier's recommendations shall be brought to the attention of Urban Utilities for resolution.

5.3.2 Switchrooms and Pre-Fabricated Buildings

Switchrooms shall be supplied complete with equipment pre-installed, including switchboards, VSDs, UPS, FIP, communications and control equipment, lighting, power outlets and HVAC units.

Prior to lifting each switchroom into position, a detailed lifting study shall be completed and submitted to Urban Utilities for approval.

Levelling nuts shall be installed under the switchroom supports to assist in levelling. Temporary bracing may be required to stabilise the structure during erection. The switchroom supports shall be non-shrink grouted into place following erection.

Transport bracing and packaging shall not be removed until the switchrooms are in final position. Once in position the bracing/packaging shall be removed and the switchroom shall be checked for visible damage sustained during transit, any such findings shall be reported to Urban Utilities immediately.

All items required to complete the installation of the switchrooms in accordance with the Supplier's instructions, Project Documentation and site requirements (e.g. stairs, handrails, external signage, cable support systems) shall be installed on site following delivery of the switchroom.

On site, switchrooms shall remain closed and locked with the transport dust seals in place to prevent the ingress of dust into the switch rooms.

Temporary protective floor coverings in switchrooms shall not be removed until the switchroom has been commissioned. Upon completion of the switchroom commissioning, the temporary floor covers shall be removed and disposed of.

Cable entry drop down boxes shall be installed to the underside of the switchrooms where required to facilitate the installation of bottom entry cabling. The installation shall be in accordance with Supplier’s instructions using the fixings and fasteners defined in the instructions. Suitable gaskets and sealing materials shall be installed to provide the necessary IP rating.

Penetrations for cable and other services access ways to new LV switchrooms and all HV switchrooms (new and existing) shall be fire rated to match the fire compartmentation of the structural element being penetrated. The penetrations shall be designed under the supervision of an RPEQ Fire Safety Engineer and the final installation method of the penetrations and method of fire sealing shall be certified by a Fire Safety Engineer. Penetrations to HV switchrooms shall comply with relevant clauses of AS 2067.

5.3.3 Switchroom Air Conditioning

Where required, the switchroom air conditioning condenser concrete pads shall be located as per the accepted site set-out drawings. These pads shall comply with the site civil standards for earthworks and concrete works and shall be in accordance with the specific condenser unit pad design drawings. Concrete pads shall not be rigidly connected to the switchroom structure by cable or pipework supports, to allow for differential movement of the pad and structure.

Outdoor condenser units shall be installed and fixed into position on rubber feet and as per the Supplier's recommendation. Units shall be orientated to ensure the fans/vents are clear of obstruction and to ensure suitable access for maintenance work (i.e. removal of filters etc.). The installation shall comply with the minimum clearances as per the Supplier's recommendations.

Refrigerant pipework shall be installed by a qualified air conditioning fitter. Refrigerant pipework shall be adequately supported and braced and installed clear of ground level. Refrigerant pipework shall be insulated and cladded as per industry best practice.

Condensate drainage line shall be run to free draining location.

Each outdoor condenser unit shall be equipped with a local isolator suitably rated for the application.

Provide slack in connecting cables and pipework to allow for differential movement of the switchroom structure and air conditioning condenser unit.

Checks that the systems are fully charged with refrigerant gas shall be completed prior to commissioning.

5.3.4 Switchgear and Switchboards

Switchboards shall be erected and assembled strictly in accordance with Project Documentation and the Supplier's installation instructions.

Switchboards supplied in multiple shipping sections shall be carefully aligned and joined together at all points from which bolts have been removed. Busbar joints shall be fitted to phase, neutral and earth busbars. Bolts used to make joints in the busbars shall be torqued to the Supplier's recommendations and marked with a cross with a waterproof marker pen. Busbar joints shall be micro-ohm resistance tested and results recorded as part of the pre-commissioning checks. Control wiring across shipping splits shall be re-terminated and point-to-point tested.

Each switchboard shall be positioned correctly in accordance with Project Documentation and aligned with the cable entry plinth/drop-down boxes and checked

to confirm the level is within the Supplier's tolerances. Where required, shims and packers shall be installed to level the switchboard to provide a square finish and avoid distortion of the frame. Switchboards shall be fixed to the floor using an appropriate anchoring system suitable for the floor surface. After installation a check shall be completed to ensure that all hinged components open freely, that all removable panels fit correctly, and that withdrawable switchgear runs freely into position without scraping or damaging the switchroom floor surface.

Switchboards and switchgear shall be thoroughly cleaned of dust and contaminants prior to energisation.

5.3.4.1 Site Installation

Where outdoor switchboards are installed on concrete plinths, at the completion of installation the switchboard base shall be sealed using a mastic or grout and procedures accepted by Urban Utilities. At sewage pump station sites, a hygroscopic barrier shall be installed between the grout and the switchboard mountings.

5.3.4.2 Consumer Mains and Metering

As part of the switchboard changeover strategy all necessary arrangements shall be made with the relevant Supply Authority for the power supply connection to the new switchboards. This includes the acquisition and installation of metering equipment, CTs, test block, fuses, electrical testing prior to energisation and certification, etc, as detailed on the drawings and/or as required by the Supply Authority and metering provider.

The works shall include submission of request forms for connection, metering changes or service alterations with the relevant Supply Authority and metering provider.

Prior to completing and submitting this form, Urban Utilities shall be consulted to verify the name of the relevant retailer for each site, together with any other information for each site that Urban Utilities may have available (such as NMI details, name of the Urban Utilities' Authorised Person, etc). Within 24 hours of submitting the Form 2 for each site to the relevant Supply Authority, a copy of the completed and signed form shall be forwarded to Urban Utilities.

5.3.4.3 Switchboard Changeover

An individual switchboard Changeover Commissioning Plan for each site shall be submitted for Urban Utilities approval. The plan shall include input and constraints advised by Urban Utilities stakeholders. Urban Utilities approval of each Changeover Commissioning Plan is required before Site Acceptance Testing for that site can commence.

TMS78 Sample Typical Changeover Commissioning Plan sets the minimum standards for the switchboard Changeover Commissioning Plan documentation.

Site telemetry, if installed, shall be maintained at all times when the site is unmanned. An independent battery backed, audible and visual level alarm shall be maintained

onsite at all times during switchboard changeovers at wet well pump stations. The switchboard changeover Commissioning Plan shall document all stages of the changeover process including use of a temporary pumping system.

5.3.5 Floor and Wall Mounted Panels and Equipment

Floor mounted equipment shall be positioned in accordance with the layout drawing and fixed to the floor with the appropriate fixings. Space for air circulation shall be allowed according to the Supplier's instructions. A minimum of 600mm shall be allowed between adjacent units on sides which have removable panels for routine maintenance access.

Wall Type	Mounting	Accepted Mounting Methods
Brick or blockwork walls	Wall	Unistrut channel (or equivalent) using spring type nut fastenings. Tops of panels shall be ~2m above floor level unless otherwise specified and aligned with tops of adjacent wall-mounted units.
Tilt-up & prefabricated panel walls	Floor	Stands bolted to the floor Brackets fixed to structural steel

Cable access to wall mounted equipment shall be provided by installing cable ladder.

5.3.6 Outdoor Distribution Boards and Control Panels

Outdoor enclosures shall be installed under shelter wherever possible. Rain shedding solar protection covers are required when exposed to sun and rain.

Cable entry to all external enclosures shall be from the bottom only, unless otherwise accepted in writing by Urban Utilities.

5.3.7 Transformer Compounds

Where fire walls are required around transformer compounds, these shall be in accordance with AS 2067. Cable penetrations within fire walls shall be cast in. Drilling or cutting penetrations in these fire walls is not permitted. Coordination of electrical services penetrations in any pre-cast fire walls shall be incorporated into planning and installation. Penetrations through the fire walls shall be fire rated upon completion of the works.

5.3.8 Power Transformers

Transformers shall be erected on prepared foundations in accordance with the Supplier's instructions. Each transformer shall be set level and the installation wheels removed (if provided).

Sealed transformers which have been filled with oil, sealed and pressurised shall not be opened in any manner that would enable the pressurising gas or oil to escape.

Non-sealed type transformers delivered filled with oil shall have any accumulated sludge drained from the bottom of the tank and a clean sample taken for testing.

Any transformers delivered to site filled with nitrogen shall be handled and prepared for energisation strictly in accordance with the Supplier's recommendations.

For transformers that are to be oil filled on site, the oil shall be filtered and filled under vacuum utilising the appropriate purpose designed vacuum/filtering equipment. All such operations shall be completed in strict accordance with the Supplier's recommendations.

Oil coolers, conservators and oil pipes transported loose shall be flushed with clean oil until all scale and foreign matter is removed. The components shall be tested for oil leaks where possible and then assembled. Any component discovered to be leaking shall be reported to Urban Utilities. Any other auxiliary equipment removed for transport shall be fitted in accordance with the Supplier's instructions.

Oil for flushing and final filling shall be supplied separately to the transformer. Immediately following flushing, the assembled transformer shall be filled with oil as necessary. Oil shall not be introduced until it has been accepted by Urban Utilities and tests have been witnessed to confirm adequate dielectric strength and water content.

Moisture content of new oil delivered separately shall not exceed 10 ppm. Moisture content of oil delivered within oil filled transformers shall not exceed 20 ppm. Oils and transformers with excessive moisture content shall be processed (dried) on site until achieving acceptable moisture content.

Dehydrating (silica gel) breathers shall be fitted (if removed for shipping) and oil added to the bowl of the breather. The silica gel shall be checked for moisture and dried out if contaminated with moisture.

Phasing shall be checked before connections are made.

Prior to lifting each transformer into position, a lifting study shall be completed and submitted to Urban Utilities for approval. The exact location and orientation of each transformer shall be as detailed in the relevant transformer drawings. Transformers shall be fixed into position onto the concrete plinths using suitable sized anchors.

Transport bracing and packaging shall not be removed until the transformers are in final position. Once installed in position, the bracing/packaging shall be removed, and each transformer shall be checked for visible damage or leaks and any such findings shall be reported to Urban Utilities immediately.

Cable termination boxes shall remain sealed prior to cable installation to prevent the dust ingress.

Prior to energisation, transformers shall be checked, and valves opened/closed as recommended by the Supplier. The final checks shall include checking for oil leaks and confirming the dielectric strength, moisture content and dissolved gasses in the oil. Transformer oil sample testing shall be undertaken by test laboratories nominated by Urban Utilities. Final moisture content of filled transformer oil shall not exceed 20 ppm.

5.3.9 Motors and Generators

Installation of rotating machinery, including lining up and final fixing to foundations, is covered in TMS 1639 *General Mechanical Works*.

Before connecting the supply to any motor, an insulation test shall be completed to ensure the insulation resistance level is in accordance with the applicable standards and the Supplier's data. Should any motor be identified to have a low insulation resistance reading, a motor test report shall be generated and issued to Urban Utilities as well as a procedure to dry-out and re-test the motor must be agreed with Urban Utilities.

Care shall be exercised when insulation testing motors fitted with thermistors, RTDs or thermocouple over-temperature protection devices. Testing shall not damage these devices.

Correct phase connections for the desired motor rotation direction shall be confirmed prior to final connection.

Large motors and generators may require barring at periodic intervals, and Supplier's instructions shall be followed in this regard.

The installation shall allow for removal of motors, generators and associated equipment with minimal disturbance to cables, associated electrical equipment and supporting steelwork.

5.3.10 UPS, Batteries and Chargers

UPS, batteries and battery chargers shall be installed in accordance with the drawings and the supplier's instructions.

Links and connections shall be checked for tightness.

Terminals and connections shall be protected with a liberal greasing of a lubricant such as petroleum jelly or to Supplier's recommendations.

Cable polarity between batteries and respective chargers shall be checked before connection.

Battery chargers, other than those fitted within equipment, shall be positioned to ensure a free flow of cooling air and that the ventilation entries/exits are clear of obstructions. A free clear space of 150mm is required from sides containing vents. Mechanical and natural ventilation shall be made ready before battery charging begins.

5.3.11 Local Control Stations

Local control stations shall be manufactured to the following requirements:

- 316 stainless steel construction, brushed, bead-blast or No. 4 finish
- Stainless steel or aluminium gland plate
- IP56
- Equipped with both a door and a hinged escutcheon
- Door shall open with a stainless steel, square key, quarter-turn lock
- Outdoor LCSs shall have a sloping roof or be fitted with a rain hood

- Where outdoor LCSs contain active or smart components, the LCS shall have a heat shield
- Fitted with isolator switches, E-stop buttons and remote/local or remote/off/local selector switches as required
- Cable entry to LCSs shall be from the bottom only

Typically, positioning and mounting arrangements of local motor control equipment shall be as defined in Project Documentation. For instances where the location is not defined, it shall be installed in a position agreed with Urban Utilities to provide a clear view of the driven machinery for reasons of safety, accessibility and practicality. Local pushbutton stations, local isolators, etc. shall be mounted as close as practicable to the driven items. In all cases, the motor shall be visible from the LCS.

LCSs shall not be installed within confined spaces.

A nameplate shall be installed on each station with the Drive Name and Equipment Number engraved as detailed in Project Documentation. Labels and nameplates shall be fixed with stainless steel screws to the LCS.

The LCS for groups of drives may be located on a common stand in a central location with labelling clearly identifying each circuit.

Pedestal mountings shall be robust and suitable for the conditions of installation.

For hazardous areas LCSs shall be in accordance with Section 5.13 Hazardous Area Installation.

5.3.12 Field Junction Boxes

Large field junction boxes (i.e. those with doors) shall comply with the following requirements:

- Of a design accepted by Urban Utilities
- Preferred materials for large junction boxes in exposed areas are powder-coated aluminium and 316 stainless steel. GRP is acceptable in sheltered areas and chemical storage areas. Junction boxes exposed to the same hazards within the same area shall be of a common material.
- Minimum IP56 ingress protection rating
- Vermin proof
- Equipped with a gland plate, earth stud, label, terminal rail, terminals, ducting and all other equipment in accordance with Project Documentation
- Equipped with door latches of the recessed quarter turn type with standard 7mm, slotted, square operating mechanism. Each junction box shall be equipped with a minimum of two latches to secure the door
- Mounted on brackets fixed to the steelwork or on a suitable stand
- Fitted with vertical terminal strips of sufficient length to accommodate the termination of all cable cores with 20% spare unused DIN rail space
- Terminal blocks shall be mounted on DIN rail. Interconnection of several terminals shall be made by means of terminal links. Partition plates shall be installed between adjoining bridged terminals.
- End plates shall be provided at the end of each group or set of terminals

- If earthing connections are required, these shall be via earthing terminals or an earthing bar
- Junction boxes shall be equipped with an adequate number of cable glands and plugs for unused cable gland openings
- Junction boxes shall be fitted with a stainless steel name plate engraved with the junction box tag number
- When fibre reinforced plastic terminal boxes are used and in the case of large metal glands, internal metal plates shall be used to reinforce the terminal box wall. These metal plates shall be connected to the earthing terminals
- Smaller metal glands that do not require reinforcing plates shall likewise be connected to earthing terminals
- Cable entries to large field junction boxes shall be by bottom entry only

Junction boxes for through connections to field equipment, equipment provided with permanent wiring, general purpose power and lighting circuits shall comply with the following requirements:

- Minimum IP56 rated
- Impact resistant
- Preferred materials are UV resistant GRP (CCG range or equivalent)
- Equipped with accepted DIN rail mounted terminal strips
- Cable entry to junction boxes for through connections shall be from the bottom. Top cable entry is prohibited
- Where approved in writing by Urban Utilities, junction boxes for through connections to building, lighting, security, fire and gas services may be installed as side entry in switchrooms, office buildings, demountable buildings and similar low-moisture environments intended for human occupation.

5.3.13 Decommissioning of Equipment and Cables

Decommissioned switchboards, including all equipment contained within the switchboards, shall remain the property of Urban Utilities and shall be locked, packaged, labelled, loaded and removed from site, and delivered to and unloaded at a location indicated in Project Documentation.

Any cathodic protection wiring within wet wells shall remain in-situ during the switchboard changeover and removal of the existing switchboard.

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

Decommissioned cables, including earthing conductors, shall be completely removed. Decommissioned cables, or parts of cable, shall not be left buried, on cable ladder, on cable trays or in conduits and pits. Conduits and pits shall be retained. Draw wires shall be pulled into empty conduits and pits. Conduits shall be sealed. In special cases and as determined by Urban Utilities, certain decommissioned cables may be left in situ. In such cases, cables shall be disconnected, cut off below ground level and tagged at both ends with a stainless steel engraved tag stating the cable number and text “CABLE

DECOMMISSIONED". Decommissioned cables left in situ shall be identified on As-Built cable route drawings and cable schedules.

5.4 Cables

5.4.1 General

Project Documentation cable schedules and/or drawings shall define the exact cable type to be installed for each application.

LV power cables shall be circular, 0.6/1 kV, copper conductor, PVC sheathed, PVC insulated, V90 type cables manufactured in accordance with the requirements of AS/NZS 5000.1.

Cables shall be installed in accordance with the cable supplier's recommendations with particular attention to minimum cable bending radii, maximum cable pulling tensions and resistance to UV radiation.

Non UV resistant cables shall be installed in either cable ladder with a cover, continuous conduit or similar to prevent exposure to UV damage. Cable sheaths or conduit shall be suitably rated for exposure to chemicals if present in the area.

Connections to portable/moveable equipment (i.e. pumps or motors with decontactor plugs) and to equipment subject to excessive vibration shall be completed using flexible cables with sufficient slack to take-up movements and vibrations.

Refer to Section 5.13 Hazardous Area Installation for the additional requirements for cables in hazardous areas.

5.4.2 Cable Entries into Equipment

Cable entries into equipment shall be as per the following:

Entry Type	Indoors (non-wetted area)	Outdoors (all wet areas)
Bottom	Preferred	Preferred
Top	By Approval	Prohibited

5.4.3 Cable Routes

The electrical drawings shall detail the general route for cables, with the exact route to be defined on- site. Cables not defined on the layout drawings shall be field routed. The site design shall define the exact route for all final cable runs from the main cable ladders (detailed on the layout drawings) to the final cable destination. In all instances coordination of the cable routes with other services shall be considered when determining final cable routes. All cable routes shall be accepted by Urban Utilities prior to commencing the cable or cable pathway installation.

Cable lengths defined in the cable schedules or listed in the drawings are estimated 'route' lengths (unless specified otherwise) and are approximate only. Exact final lengths shall be verified on site prior to installing and/or cutting of cables. Significant difference

in designed versus final cable lengths (>10m or >30% longer) shall be referred to the designer for verification before cutting and installation, as cable sizes may be affected.

Main cable routes above and below ground shall be shown on cable route drawings superimposed on the site layout drawing. Cable route and pit layout drawings shall be updated to As Built with GPS co-ordinates of the installed cable routes.

Adequate space shall be confirmed to exist on the cable ladders and in conduits for the intended cable installation prior to commencing the cable, ladder or conduit installation.

Cables shall be installed in accordance with the method of installation (including spacings, bedding material and backfill) as defined in Project Documentation. Cable sizes will have been calculated based on the method of installation as defined and as such neither cable size nor installation detail shall be changed without approval from Urban Utilities. Cables shall be installed neatly to ensure they can be readily traced and identified from origin to destination. Cables shall be installed to avoid crossovers with other cables. Installations shall be in accordance with the requirements of AS/NZS 3000 and AS/NZS 3008.1.1.

5.4.4 Cable Handling and Installation

Due to the significant size, type and lengths of cables to be installed, it may be necessary to utilise specialised equipment for handling and installing the cables. Accompanying this specialised equipment will be the need for the use of experienced personnel and proven work procedures. All cable handling and installation plant and equipment shall be accepted by Urban Utilities prior to use.

Under no circumstances shall metal levers or tools be used in direct contact with cables during installation unless of a proprietary type specially designed for the purpose.

Care shall be taken to protect cable, cable drums, equipment and personnel during handling and installation. Cable drums shall be rolled only in the direction indicated on the side of the drum.

Protective battens and covers on cable drums shall not be removed until immediately prior to installation.

Cable shall be unrolled from reels, under controlled tension in a manner that will prevent kinking and crushing of the conductors. During installation cable drums shall be braked to avoid over-running.

Winches used to draw cables shall have an adjustable setting to limit the pulling tension. The pull tension adjustment shall be set to ensure that the cable supplier's maximum pulling tension is not exceeded. Cable jacks and lifting equipment shall be sized and rated for the weight and size of the cable drum.

At no time shall a cable takes up a radius less than its permissible bending radius.

External protective sheathing, serving or jacket shall remain intact and undamaged.

Cables shall be drawn into position on rollers unless otherwise accepted by Urban Utilities. Sufficient rollers shall be used to ensure that the cable is kept clear of the ground and other obstructions. Purpose designed change of direction rollers shall be used at changes in direction.

Cables shall not be pulled using the conductors. HV and larger LV cables shall be pulled using suitably rated swivels, pulling eyes, cable stockings and/or other load spreading means to prevent distortion and/or damage to the cable end.

Cable pulling lubricants shall be checked for compatibility with the cable prior to use.

Cable installation lengths shall be carefully measured and cut to ensure sufficient cable length to effect the termination whilst minimising cable off-cuts. The ends of high voltage cables shall be sealed immediately after cutting using suitably sized resin filled heat shrink cable caps. Sealing of LV and control cables shall be done immediately if exposed to severe dampness but, in any case, shall be sealed if the next cut will not be made during the following seven (7) days.

During installation cables shall be clearly labelled with temporary labels at both ends.

5.4.5 Cable Management and Cable Records

When cable is supplied in drum lengths allocated for specific circuits, site records shall be maintained to ensure the correct cable drums are used for the nominated circuits.

Unless otherwise agreed, a cable pulling schedule and cable drum schedule (or similar) shall be maintained to record the actual lengths installed. These records shall be used to monitor the efficient usage of cable and to predict any shortfalls. Final installed cable lengths shall be recorded on the cable schedule as 'As- Built' information.

Records shall demonstrate continuous monitoring and reporting of cables stored on site. Adequate levels of cables (excluding Urban Utilities supplied cables) shall be maintained to ensure that the installation schedule is not delayed due to cable shortages. Similarly, Urban Utilities shall be advised of any possible future shortages in Urban Utilities supplied cable to ensure replacement stocks can be ordered and delivered without impacting on the installation schedule.

"As-Built" drawings shall be provided of cable routes including any deviations and their approval documentation. Digital photos of underground cable installations shall be provided where defined in the ITPs as part of handover documentation.

5.4.6 Single Core Cables and Clamping

Where three phase circuits are underground or run on cable ladder using single core cables, the A, B and C phase cables shall be grouped together touching in a trefoil formation with the trefoil formation being maintained as far as possible up to the cable glands. For underground conduit installations, nylon cable ties shall be utilised to maintain the trefoil formation.

For cable ladder installations, cable cleats or equivalent systems shall be utilised to provide the trefoil formation. Systems for clamping cables shall be accepted by Urban Utilities prior to use. Under no circumstances shall improvised devices be used for clamping cables in trefoil formation.

Cable cleats and equivalents shall be:

- Compliant with IEC 61914

- Type tested to be suitable for the prospective peak fault level of the cable and the spacings between adjacent cleats
- Installed at intervals such that there shall be no cable damage on fault
- Installed at intervals to prevent flexing of cables on fault

For vertical runs of greater than 5m, only cable cleats shall be used.

Parallel runs of single core cables shall maintain a trefoil configuration with a minimum of one cable diameter spacing between trefoil groups, with each group being a mirror image of the adjacent trefoil group.

Single core cables serving as neutral conductors shall be run adjacent to the respective trefoil group and secured by stainless steel cable ties with plastic sheathing (for cable ladder installations only).

Single conductor cables carrying alternating current shall not pass through any closed ferrous circuits unless accepted by Urban Utilities.

5.4.7 Cable Securing

Cable ties installed on outdoor cable ladder shall be stainless steel with plastic sheathing. In indoor areas, cable ties for LV cables 70mm^2 or smaller may be nylon. Cable ties shall be applied to multicore, neutral, earth and equipotential bonding backbone cables as follows:

Cable Type	Horizontal Ladder	Sloping or Vertical Ladder	Direction Changes & 2000mm either side
LV ≤70mm^2	Every 3000mm	Every 300mm	Each rung
LV >70mm^2	Every 600mm	Every 300mm	Each rung
HV	Every 600mm	Every 300mm	Each rung

The ties shall be fixed with a specialist tension and cutting tool.

The maximum number of cables tied together shall be no greater than four (4).

Cables installed in vertical conduits shall be tied at intervals not exceeding 4m to prevent excessive weight bearing on the cable.

Cables supported from catenary wires shall be secured using stainless steel plastic sheathed cable ties at intervals of not more than 1m.

5.4.8 Cable Segregation

Wherever practicable, critical cables for duplicate feeds and equipment shall run via separate routes to increase security of supply.

Cables dedicated for emergency services signals and safety systems shall, as far as practicable, be in separate routes to cables used for other services. Special consideration shall be given to routing and segregation of cables, to minimise the effects of fire on emergency and essential supplies and production operation.

Cables shall be segregated into separate groups according to susceptibility to electromagnetic interference as follows:

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

The segregation of groups shall not be less than the distances shown below unless run in separate conduits or an earthed segregation barrier is utilised:

	Level 1	Level 2	Level 3A	Level 3B	Level 4
Level 1	0	150mm	300mm	300mm	450mm
Level 2	150mm	0	150mm*	300mm	450mm
Level 3A	300mm	150mm*	0	0	300mm
Level 3B	300mm	300mm	0	0	300mm
Level 4	450mm	450mm	300mm	300mm	0

* Note that within cable pits, the segregation distance between cables of susceptibility 2 and 3A may be reduced to 50mm without additional barriers.

Earth cables shall run alongside the power cable when earthing associated electrical equipment.

Fibre Optic cables with a non-metallic sheath shall maintain a minimum separation of 50mm from all cables of Level 1, 3A and 3B, 300mm from Level 4 and may be run together with cables of Level 2.

HV cables shall be run in separate cable ladder or conduit to all other cable groups.

DC wiring shall not be run with AC wiring.

5.4.9 Cable Spacing

Unless otherwise specified, the spacing between individual cables shall be as follows on cable ladders:

Cable Type	Layers	Cable Spacing
Instrumentation Communications Control LV Power (≤20A)	Multi-layered to 75% of ladder depth	Bunched

Cable Type	Layers	Cable Spacing
LV Power (>20A and ≤16mm^2)	Up to 2 layers	Bunched (multicore), one (1) cable diameter spacing between trefoil groups
LV Power (>20A or >16mm^2)	Single layer	Touching (multicore), one (1) cable diameter spacing between trefoil groups
HV Power	Single layer	One (1) cable diameter spacing between cables or trefoil groups

Cable installation designs shall be supported by calculations.

5.4.10 Cable Bending Radii

Cable bending radii shall be as large as practical, and shall not be less than the Supplier's recommended minimum bending radii. Relevant cable data sheets shall be kept available on site so bending radii may be referred to during installation. Particular attention shall be given to the minimum installation bending radii to ensure it is maintained for all cables while under tension during cable pulling.

5.4.11 Cable Jointing

Cables shall be installed in continuous, unbroken lengths without joints. Joints in cables are not permitted except for the following:

- Junction boxes for lighting
- Junction boxes for end connections into field equipment as per OEM recommendation
- Cable extensions or repairs where replacing entire existing length is not feasible. Urban Utilities will determine feasibility
- Other special circumstances as approved and specified by Urban Utilities

In the event of any existing cables being too short for termination into a new switchboard, then the cables shall be replaced throughout their entire length.

Where required, cable joints shall be as per the table below:

Cable Type	Above Ground	Underground
Fibre Optic	Fibre optic splice enclosure (bottom cable entry only)[1] Fibre Optic Break-Out Trays (FOBOTs)	Fibre optic splice enclosure inside a pit[1]
Control & Instrumentation	Junction boxes, via terminal strips[2]	Not permitted
LV Power	Junction boxes, via terminal strips[2] Approved jointing kit installed in ladder[1]	Approved jointing kit inside a pit[1]

Cable Type	Above Ground	Underground
HV Power	IEC 60502-4 compliant jointing kit installed in ladder[1]	IEC 60502-4 compliant jointing kit inside a pit[1]

Notes:

1. Where approved or specified by Urban Utilities only
2. As required for lighting or as per OEM recommendations for field equipment only

Multicore cables to be jointed shall be installed such that the spiral lay of the cable cores shall be in the same rotation throughout the complete cable length.

Urban Utilities shall approve the cable jointing kits for all applications. These kits shall be selected specifically to suit the voltage grade, configuration and type of cable. The Supplier's installation instructions for the jointing kits shall be kept available for on-site reference.

Underground jointing kits shall be suitable for installation in saline, permanently saturated soil.

Joints in underground LV & HV cables shall be completed in a pit fitted with a clearly marked cover and designed to minimise water ingress.

Underground HV cable joints shall be installed in pits and, where possible, elevated at least 100mm from the floor of the pit by means of a supporting frame. The joint shall be arranged so as to provide some cable slack to minimise stress on the joint caused by the expansion/contraction of the cable due to operating and environmental temperature variations.

Armour cages shall be utilised for all armoured cables to maintain the continuity of the armour across joints.

Cable joints shall be completed by suitably qualified and experienced personnel.

Above ground joint markers and locations of pits containing joints shall be recorded as part of the As-Built documentation for all underground cable joints.

Locations of cable joints on above ground cable ladder shall be detailed on the cable layout design drawings to form part of As-Built information. On-site these locations shall be identified with suitable markers or signage.

5.4.12 Cable Terminations

5.4.12.1 General

Cable cores and screens shall be terminated in accordance with the recommendations of the supplier of cables, glands, switchgear and lugs.

Terminations shall be completed in a neat and tidy tradesman like manner as per best practice. Cables shall be adequately dressed and supported into the point of termination with a generous sweep to ensure minimal stress on the termination and sufficient slack to re-terminate the cable if required.

Correct phasing/connection of all cables shall be verified prior to final connections being made.

Motor cable terminations shall be completed to enable at least two cable core connections at the motor terminal box to be interchanged without having to make off the cable again.

Cables terminating to equipment with significant vibration or operational movement shall have sufficient slack to facilitate the anticipated movements in the equipment without placing any undue strain on the cable or termination.

In instances where multiple cables are to be terminated into a termination box with a single entry a local breakout box and flexible heavy duty PVC conduit shall be utilised to facilitate the termination. Similarly, where oversized cables are to be terminated into a small termination box a local breakout box and flexible heavy-duty conduit (not steel) shall be utilised to facilitate the termination. Such arrangements shall be accepted by Urban Utilities prior to commencement of works.

5.4.12.2 Lugs, Ferrules, Terminals and Bolted Connections

Conductors shall be terminated as per the following:

Conductor Size	Terminal Connections	Bolted Connections
≤10mm^2	Pre-insulated ferrules / lugs: • Tunnel terminals – bootlace type • Stud terminals – ring type • Other screw-in terminals – fork/spade type preferred	Copper conductors: • Uninsulated tinned copper lugs, ring type Aluminium conductors: • Bi-metallic lugs, ring type (for connecting to dissimilar metals)
≥16mm^2	N/A	

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

- Lugs and ferrules shall be crimped using a ratchet crimping tool (Grafoplast YAC-5 or accepted equivalent) prior to insertion into the terminal
- Crimping shall not be affected using the terminal screw alone
- Wires shall be fitted with labels of the Grafoplast 'TRASP' system, the Grafoplast SI2000 system or an accepted equivalent system. Labels shall be correctly sized for the conductor.
- Flat and spring washers or similar accepted locking devices shall be used on all stud terminations
- Not more than two wires shall be terminated on any one stud type terminal.
- Not more than one wire shall be terminated in any tunnel type terminal
    - Where multiple connections are required on tunnel terminals, multiple terminals linked with proprietary terminal link bars shall be used.

- Pre-insulated ferrules and lugs shall not be used to terminate conductors where a suitable terminal is not provided for that purpose. Under no circumstances shall earth bar connections, equipotential bonds, conductors exposed to the environment or conductors likely to undergo movement be terminated using pre-insulated ferrules or lugs.

The following requirements apply to cable lugs for bolted connections:

- Hexagonal crimping dies shall be used for multi-strand conductor cables ≥16mm^2
    - Crimping dies shall emboss the size of die used on the cable lug
    - Crimped lugs where the metal has extruded radially shall not be accepted
    - Only compression tools recommended by the supplier of the lugs shall be used.
    - Where hand operated, the tools shall be of the type which will not release until full compression is applied.
    - The Supplier's operating instructions for the crimping tools detailing the method for crimping the different types of lugs shall be kept available for on-site reference
- Stainless steel bolts, nuts and Belleville washers shall be used to secure bolted lug connections
- Where required a torque wrench shall be used to tighten termination bolts to the appropriate setting as defined by the equipment supplier. Torque marks using permanent marker or other accepted method shall be provided for all torqued termination bolts.
- The maximum clearance diameter of any cable lug or busbar hole shall not be more than 110% of its mating stud or bolt diameter
- Cable lugs shall be sized and suited specifically for the application with no modifications to the cable lugs permitted
- Lugs on cables exposed to the weather shall be sealed to prevent ingress of moisture and corrosive gas into the cable
- Suitable lug sealant systems are typically heat shrink and/or bituminous products. Proposed sealing systems shall be accepted by Urban Utilities before use.
- Specialised tools, accessories and techniques shall be utilised for the termination of cables with aluminium conductors.
    - Bi-metallic lugs shall be used where aluminium conductors are to be terminated onto switchgear of dissimilar metal
    - Manufacturer instructions regarding crimping onto aluminium conductors shall be strictly followed, including correct matching of materials and the use of manufacturer recommended crimping tools

The following requirements apply to terminals and terminal block:

- Terminals shall be rail mounted, clip-in, tunnel type or spring clamp terminal type, and shall incorporate vibration resistant, captive pressure screws which shall not bear directly on the wire.

- Knife gate marshalling terminals with minimum size for 2.5mm2 conductors shall be installed for all control and instrument cable cores.
- All I/O wiring shall contain fuse(s) to protect the card and individual channels of the card. Where fuse terminals are provided a minimum 10 off spare unused fuses shall be provided inside the panel.
- Terminals shall be suitable for copper conductors
- Terminals shall be rated minimum 600V
- Terminal block insulation shall be of a non-grid, non-hygroscopic, non-tracking, non-flammable material
- Terminal shall have minimum ingress protection rating of IP2X to prevent accidental contact during inspection and maintenance
- Terminals shall be sized to suit the conductor size and current rating (minimum of 2.5mm^2 conductor)
- Terminals with hinged components, such as fuse and disconnect terminals, shall be hinged on the right-hand side unless advised otherwise
- Single level test/disconnect terminals shall be used for marshalling analogue I/O wiring
- Dual level terminals may only be used for marshalling digital I/O wiring in existing control panels where spare space is limited. The upper level terminals shall be odd numbered and the lower level terminals shall be even numbered. Multiple level or tiered terminals shall not be used for other applications including new control panels unless accepted by Urban Utilities in writing
- Push-in clamp type terminals shall not be used unless approved by Urban Utilities
- Separately mounted terminal blocks/strips shall be provided for each voltage level
- Separately mounted terminal strips shall be provided for different wiring applications including control, instrumentation and power wiring
- Adjacent groups of terminals shall be separated from each other using space, barriers or earth terminals
- Terminals shall be arranged such that all cores (including spare cores and screens) of multicore and twisted pair cables fan out and terminate in a logical sequence onto consecutive terminals of a common terminal strip. The terminals strip group label in this case is the same as the cable tag number. Terminating screens of instrument cables direct to the instrument earth bar is not accepted
- Terminals for internal wiring shall be arranged such that all ‘commons’ or ‘positives’ are grouped together and bridged with a continuous link on consecutive terminals
- Each strip of terminals shall be clearly identified with a group label. In addition, each terminal in the strip shall be labelled with a unique number
- Terminal strip labels and numbers shall be defined on the relevant drawings and Project Documentation
- I/O marshalling terminals shall be grouped per I/O module and the groups of terminals shall be separated by an end bracket which is labelled with the associated controller rack and slot number

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

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

- Terminal points inside cabinets, junction boxes etc. shall be marked or painted blue in accordance with AS/NZS 60079.14.
- Terminals used for intrinsically safe circuits shall meet the requirements of AS/NZS 60079.25 for creepage and clearance. Minimum terminal size shall be 2.5mm^2 or approved equivalent
- Intrinsically safe terminals shall be located at least 50 mm from non-intrinsically safe terminals.

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

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

5.4.12.3 Screened and Armoured Cables

The following requirements apply to screened and armoured cables:

Screen or Armour Type	Earthing Requirements	Glanding Requirements
HV cable screens	Earth at both ends	Cables shall be glanded as detailed in the standard installation drawings
LV cable screens (including VSD cables)	Earth at both ends	Purpose-designed, EMC reducing metallic glands required
Instrumentation, Communication & Control screens	Earth at PLC panel or MCC end only	Non-metallic glands permitted. Maintain screen as far as possible up to the termination (i.e. do not cut screen off at the gland)[1]
Cable armour	Earth at both ends	Purpose-designed armoured cable glands required In certain applications (i.e. painted gland plates) it may be necessary to use a gland equipped with a brass earthing tag or serrated washers to ensure a good earth bond

Notes:

1. The screen on all instrumentation and control cables shall maintain continuity through all intermediate junction boxes between the device and the marshalling/control panel.

5.4.12.4 Termination of HV Cables

Project Documentation will specify the HV cable termination kits for all applications. These kits shall be selected specifically to suit the voltage grade, configuration, type of cable and type of switchgear.

HV cable termination kits shall be in accordance with the requirements of IEC 60502-4.

Suppliers' installation instructions for the termination kits shall be kept available for on-site reference.

HV cable terminations shall be completed by suitably qualified and experienced personnel.

Prior to commencing HV cable terminations system phase rotation on the switchboard shall be verified to be as per the site standard.

Suitable compression dies and tools sized for the application shall be utilised during the cutting and crimping operations.

Cables shall be adequately clamped and supported at the termination to minimise stress on the cable, gland and terminations caused by the weight of the cable and the expansion and contraction of the cable due to operating and environmental temperature variations.

Each core shall have colour heat shrink on termination lugs or similar to identify the phase.

Identification and procurement of miscellaneous materials and consumables necessary for the termination of the cables shall be carried out in a timely manner prior to commencement of the termination works.

Prior to commencing termination works, all high voltage cable terminations shall be reviewed and any issues (e.g. the need for drop-down boxes at switchrooms etc) identified early so as not to impact on the construction programme. Particular attention shall be given to the tail lengths of the termination kits to ensure there is sufficient space available within the cable termination compartment to facilitate the termination. Such issues shall be brought to the attention of Urban Utilities' for resolution.

5.4.12.5 Termination of LV Cables

LV cables shall be terminated through a gland entry and the tails shall be fitted with crimped cable lugs of the correct type and size for the cable. Heat shrinkable plastic sleeves shall be fitted to seal cable insulation to lug only after continuity tests are completed and after the joint has been inspected by Urban Utilities if required. The heat shrink on each lug shall be colour coded to identify the phase.

Correct phasing, polarity and conductor identification of cables shall be verified prior to final connection throughout the installation.

Cores of large power cables shall be arranged to ensure minimal stress on the termination and cable.

Each cable core shall have sufficient spare length to allow for replacement of lug or swapping of phases.

Large power cable terminations shall be reviewed and any issues (e.g. the need for drop-down boxes at switchrooms etc) identified early so as not to impact on the construction programme. Such issues shall be brought to the attention of Urban Utilities for resolution.

5.4.12.6 Termination of Control & Instrumentation Cables

Cores of single cables shall be terminated in consecutive terminals and in logical order, where possible.

Each spare core in every control and instrument cable shall be terminated at spare terminals in switchboards and LCSs unless specifically indicated otherwise on termination drawings.

Cables which terminate to field devices shall have a single or double coil of cable approximately 150 mm diameter before the cable gland. The cable loop may be within

the cable ladder or duct if within 2m of the cable field termination, appropriate for the installation and accepted by Urban Utilities.

Where insufficient equipment terminals are provided to terminate all cables including spare cores, additional terminals shall be installed.

The tails of multi-core cables shall be of sufficient length to allow connection of each core to any terminal on the associated terminal strips. The tails of cables shall be neatly laced up using nylon cable ties. Excess cable tie lengths shall be cut with a specialist cable tie trimming tool. Side cutter pliers are not permitted for trimming cable ties.

Screened cables shall have the screen earthed as detailed in the relevant Project Documentation. The screen on all control and instrumentation cables shall maintain continuity through all intermediate junction boxes between the device and the marshalling/control panel. Where practical the screen shall remain on cables within the enclosures (i.e. not stripped at the gland) up to the termination destination.

RTD breakout boxes and flexible steel conduit shall be installed where required to facilitate the termination of the RTD cables at the motors. Field cabling associated with RTDs can be connected directly to the control system analogue input channel.

Where cables or wiring terminate into plug connectors, such connectors shall be equipped with retaining devices to prevent accidental disconnection.

Where surge barriers are installed for control circuits and instrument loops, field cables shall connect direct to the surge barrier terminals. Neutral conductors on load side of the surge barriers shall be identified and isolation maintained from unprotected power supply neutral conductors.

5.4.12.7 Terminations at Field Equipment using Flexible Cords

Where the instrument or field equipment has insufficient cable or conduit entries for the cables to be fitted, a suitable junction box shall be provided for accepting the cables. The cores shall not be joined in the box but pass through to the instrument terminals.

Where an instrument has flying leads and no terminal box, a terminal box with sufficient suitable terminals shall be provided. A conduit seal may be required to separate instrument enclosure from the junction box. A multi pin plug and socket is not an accepted alternative arrangement for this application.

Solenoids, proximity switches, level switches and other items of equipment with DIN type plugs or similar connections not suitable for direct termination of ordinary circular cable shall be connected in the following manner:

- The supply cable shall be terminated at a junction box close to the device
- If the item is supplied with a plug, then flexible cord with 0.75 mm^2 conductors shall be run from the junction box to the plug

- If the item is supplied with a flexible cord (e.g. level switch), the cord shall be connected to the junction box
- The flexible cord shall be run in conduit for the whole of its length and shrouds fastened at each end with cable ties
- This type of termination shall be supplied if required for solenoids or field instruments

Note: 'Blue Point' style connectors shall not be used.

5.4.12.8 Termination of Earthing Cables

Earthing cable terminations shall be made using compression lugs for bolted connections, except where tunnel-type terminals are provided inside electrical equipment. Utilux or equivalent pre-insulated lugs are not accepted for terminating onto earth bars, or for equipotential bonds.

Earth cables shall be terminated on a copper busbar, or an equipment earth terminal. Not more than one earth cable shall be terminated on any one terminal.

5.4.13 Cable Glands

Cables entering equipment shall do so through cable glands conforming to IEC 62444 (or equivalent).

Cable glands shall generally be of the following materials:

Gland Size	Indoors	Outdoors	
		Low H_2S Exposure[3]	High H_2S Exposure[3]
≤M25	PVC or Nylon[1,2]	Nickel-plated brass	316 stainless steel
≥M32	Nickel-plated brass		

Notes:

1. PVC and nylon glands may be used outdoors by written approval only. Approval will be granted under special circumstances only (e.g. due to a harsh or corrosive environment where metallic glands are not suitable).
2. For enclosures requiring at least one metallic gland, metallic glands shall be used for all cable entries. Enclosures with a mixture of metallic and non-metallic glands are not permitted.
3. For the purposes of cable gland selection, areas with high H_2S exposure include RRC inlet works, sewage pump station wet wells and other areas identified in Project Documentation where high levels of H_2S are expected as part of normal operation. Luggage Point RRC is a special case with H_2S corrosion observed throughout the plant. All cable glands at Luggage Point RRC shall be 316 stainless steel.

In general, cable glands shall conform to the following requirements:

- Glands shall maintain at least the same degree of protection against ingress of dust and moisture as the equipment enclosure

  - One cable gland per cable shall be provided
  - Glands shall be of the mechanical compression type
  - Glands shall include seals to outer cable sheath as a minimum
  - Glands shall be equipped with nylon sealing washers to be installed between the gland and the outer face of the equipment or gland plate
- Glands shall include integral facilities for securing and earthing the cable braid, screen or armour where required
- Glands shall be fully inspectable without the need to disturb cable terminations or the earth continuity of screen or armour clamping and earthing
- Glands shall have ISO metric threads
  - In all instances glands shall be equipped with a suitable thread length to suit the application to ensure accessories such as serrated washers, earthing tags, lock nuts and the like can be securely fixed
- Where adaptors or reducers are required to match cable glands to entry sizes or thread forms, the following requirements apply
  - Adapters shall be made of the same material as the gland
  - Adaptors and reducers shall maintain the IP rating of the gland

The following requirements apply to the installation of cable glands

- The correct gland and installation procedure shall be selected for each cable to the supplier's recommendations and confirmed by the on-site measurement of cable dimensions
  - All personnel who make off the cable glands shall be fully conversant with the supplier's procedures before making off any gland
- To prevent ingress of dirt and debris conduit and cable glands shall be shrouded and shrouds fixed with cable ties or other method accepted by Urban Utilities
  - Correctly sized cable shrouds shall be used to suit the cable size
- The following requirements apply to entries into equipment
  - The equipment gland entry or gland plate shall be punched, drilled or tapped as necessary for the installation of the glands
  - Cable glands shall be fitted with a nylon sealing washer and secured with a lock nut and serrated washer or screwed into the equipment
  - For drilled and tapped entries the same accessories shall be used where practical to do so
  - All glands shall be securely fixed to the gland plate or cable entry facility.

Cable entries are made into equipment shall achieve the following:

- The correct entry point for cables into equipment shall be verified prior to installation
- Cables shall be suitably supported where they approach gland entries to ensure a perpendicular entry into the gland and to prevent any forces on glands which may render the IP seals ineffective
- Where multiple cable entries occur, each cable gland shall be located to facilitate a neat installation and minimise cable and cable core inter-weaving

- The glanding and termination of cables in enclosures and panels shall be completed to provide sufficient facility for future additional cables to be installed and terminated.
- Any spare or unused gland penetrations shall be plugged using metallic sealing plugs to maintain the IP rating of the equipment
- Purpose designed glands shall be used for RFI screened power cables (e.g. LV VSD cables) to provide suitable earthing of the screens and armour. Both ends of the screen and armour shall be earthed
- Armour shall typically be earthed using proprietary purpose built VSD/armour cable glands and the gland plate
- However in certain applications (i.e. painted gland plates) it may be necessary to use a gland equipped with a brass earthing tag or serrated washers to ensure a good earth bond.

Where non-metallic enclosures are used, means shall be provided to preserve the electrical continuity of the armouring of cables by bonding the cable glands to each other and to the earth. Generally this shall be achieved using brass earthing tags.

All cable glands to be used in hazardous areas shall be rated for the HA zone classification and protection technique for the particular application and shall have current IEC Ex, AusEx or ANZEx certification provided in the HA Dossier. Refer to Section 5.13 Hazardous Area Installation.

5.4.14 Cable Identification

Cables shall be numbered and tagged in an accessible position at both ends of the cable by means of tags bearing the cable numbers listed in the cable schedule. These shall be stainless steel, 12mm wide by 0.5mm thick, laser etched with the number and attached to the cable with cable ties through holes at each end of the label. UV exposed labels shall use plastic-coated stainless steel cable ties. Cable ties shall be tensioned and trimmed with a specialist tool.

Tags as per Project Documentation shall be installed on each cable:

- At start and end of cable
- On either side of floor and wall penetrations and transit frames
- At the equipment entry point just before the gland

Within equipment (e.g. MCCs, marshalling panels and field junction boxes), plastic numbered tags attached with nylon cable ties shall identify groups of cores with the number of the cable to which they belong. The cable inner sheath shall be terminated as close to the relevant terminals as possible in order to make it easy to ascertain the cable identification of the cores. If necessary, additional cable tags shall be installed on groups of cores for complete identification.

Where two or more labels occur at a common point then all such labels shall be readable from the same direction being left to right and bottom to top.

At switchboards and other places where both sides of a cable gland plate cannot be viewed from the one location, cable number tags shall be fitted to cables both above and below the gland plate.

Refer to TMS1647 *Equipment Tag Naming Technical Specification* for cable tag naming requirements.

5.4.15 Core Identification

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

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

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

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

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

5.4.16 Above-Ground Cables

5.4.16.1 General

Above ground cables shall be reticulated along pathways that provide suitable mechanical protection. Typically, this shall be achieved using cable ladder. Where cables leave the cable ladder to terminate at field equipment, heavy duty rigid or heavy duty flexible conduit shall be installed to provide the mechanical protection of the final length of cable. Running cables inside Unistrut channel with no additional protection is not accepted.

Where cables and/or conduits and ladders are run across structural points intended to allow for expansion, contraction or differential settlement, provision shall be made for such movement to ensure that the cables and their support accessories are not subject to stress.

5.4.16.2 Cable Ladders

The following requirements pertain to cable ladder design:

- Cable ladder classification shall be selected as per the following criteria:
  - Minimum specification for new HV cable ladders shall be NEMA 20C.
  - Minimum specification for new cable ladders for primary LV cable routes shall be NEMA 20C. Primary LV cable ladders routes are defined as those under or within switchrooms.
  - Minimum specification for all other new cable ladders shall be NEMA 12A,12B or 12C
  - Selection shall consider final cable loads including spare capacity, unsupported span lengths, cable ladder maximum deflection and the need to mechanically protect the cables
- When fully loaded, the sag of cable ladders shall not exceed 1/100 of the span.
- Cable ladder systems, including covers, shall be capable of withstanding the conditions outlined in Project Documentation.
- Cable ladder systems shall be designed in accordance with manufacturer's recommendations and standard installation drawings developed for the project.
- Cable ladder installations shall be equipped with 20% spare capacity upon completion of the cable installation. New cable support systems, except where approved by Urban Utilities, shall allow for 20% spare capacity at the completion of detailed design.
- Cable ladder sections and fittings shall be designed to span between supports as detailed in Project Documentation. The design loads for cable ladders shall be suitable for the following criteria:
  - For general loading and cable loading including spare future capacity
  - For wind loading design parameters specific to the site conditions

Unless otherwise specified, all cable ladders shall be of the following materials:

Environment	Materials of Manufacture		
	Ladder	Fixing Hardware (Nuts, Bolts, Washers etc.)	Supports
Water Network Assets	Hot dip galvanised steel	Hot dip galvanised steel	Hot dip galvanised steel, welded or bolted to building structures
Coastal Areas (within 2km of sea shore)	Marine grade aluminium/stainless steel	316 stainless steel with UV-resistant insulating spacers & washers to separate dissimilar metals	316 stainless steel, welded or bolted to building structures. Use insulating spacers to separate dissimilar metals

Environment	Materials of Manufacture		
	Ladder	Fixing Hardware (Nuts, Bolts, Washers etc.)	Supports
Sewage Treatment Plants & Sewage Pump Stations	Marine grade aluminium/stainless steel	316 stainless steel with UV-resistant insulating spacers & washers to separate dissimilar metals	316 stainless steel, welded or bolted to building structures. Use insulating spacers to separate dissimilar metals
Corrosive Chemical Dosing & Storage Areas	Heavy duty fibreglass, glass-reinforced plastic or other approved non-metallic materials	Manufacturer-recommended fixing hardware. Materials shall be appropriate for the application	Manufacturer-recommended brackets and supports. Materials or treatments (e.g. coatings) shall be appropriate for the application

Notes:

1. Non-metallic cable ladders shall be installed strictly to the manufacturer's recommendations. Location shall not allow ladders to be exposed to mechanical damage.
2. Aluminium cable ladder installations shall be designed to eliminate the effects of galvanic corrosion using spacers where aluminium ladder would come into contact with galvanised steel or stainless steel.

The following requirements pertain to cable ladder construction:

- Cable ladder rung spacing shall not exceed 300mm
- Cable ladder shall be mounted to maintain 300mm clearance between ladders stacked vertically and at least 150mm clearance under structural steel sections when crossing at right angles and 250mm when running parallel and below structural steel or floor plate
- Cable ladder sections shall be bolted together using splice plates
    - The splice connection shall be designed to transfer the full structural capacity of the cable ladder rail section and accordingly shall be capable of being positioned anywhere along the ladder span
    - Each splice plate shall be connected to the individual ladder sections using at least two (2) bolts
- Proprietary fittings (bends, tees, risers etc) shall meet the following requirements:

    - Fittings shall be selected to suit the bending radii of the cables on the ladder
    - Fittings shall be structural steel. Fitting rails shall follow the same profile as the cable ladder to form a more self-supporting assembly and improve the rigidity of the large radius bend fittings
    - Ladders and fittings shall be connected with bolted wrap-around sleeve type splice plates for additional strength
- Where suitable proprietary fittings are not available customised welded fittings shall be on- site fabricated
    - Any such on-site fabricated cable ladder fittings shall be to the satisfaction of the Urban Utilities
    - Fabricated non-proprietary steel bends and tee fittings where indicated in Project Documentation shall be supplied as part of the structural steelwork
- Cable ladders shall be fitted with a segregation barrier strip where defined in Project Documentation. All barrier strips are to be of similar material and finish as the ladder to which it is fitted and shall be fixed in accordance with the Supplier's recommendations.
- Bolts shall not protrude into cable ladders such as to cause damage to cables during installation. Bolts used for cable ladder joints and equipotential bonding shall be cup head bolts, with the bolt head inside the run of cable ladder
- All cable ladders shall be supported as detailed in the standard installation drawings
    - Cable ladders shall not be supported directly under splice plates
    - Thermal expansion gaps shall be provided every 50 metres on straight runs exposed to direct sunlight
    - Expansion joints shall be fitted according to the cable ladder supplier's recommendations
- Unless detailed otherwise, all cable ladder brackets and supports shall be configured as detailed in the standard installation drawings
    - Typically, brackets shall be fixed via welding or using bolts through holes punched/drilled in the steelwork
    - Brackets may be fixed to structures using approved proprietary cyclone-rated clamps. Clamps shall be installed so as to avoid damaging anti-corrosion coatings or compromising the structural integrity of the structures or brackets.
    - The configuration of any non-typical cable ladder installations shall be accepted by Urban Utilities prior to installation.
    - Proprietary cyclone rated hold down clamps shall be utilised for the fixing of cable ladders to brackets with provision to enable the cable ladder system to expand and contract

Generally all cable on ladders shall be protected from direct sunlight and mechanical damage with cable ladder covers. The following requirements apply:

- Covers and backing plates shall be of similar material, thickness and finish as the ladder to which it is fitted

- Covers shall be securely fastened in accordance with the supplier's recommendations.
- Horizontal cable ladders shall have covers
    - For exposed runs covers shall be peaked in the middle at 30° pitch
    - For multi-tiered horizontal cable ladders only the top cable ladder shall require covers unless lower ladders are exposed to solar radiation
- Vertical cable ladders shall have cable ladder covers and backing plates
    - For multi-tiered vertical cable ladders, only the exposed sides of the outside ladders shall require covers or backing plates
    - Vertical cable ladders that run up a wall at an offset of ≤450mm do not require a cover or backing plate on the side facing the wall
- Side-mounted cable ladders shall have vented cable ladder covers and perforated backing plates
    - Side-mounted cable ladders that run on a wall at an offset of ≤450mm do not require a cover or backing plate on the side facing the wall
- Covers are not required within or beneath buildings
- Covers shall be installed on cable ladder sections, tees, crosses, risers and bends where required above

Cable ladders shall be bonded as follows:

- Each length of ladder and all fittings are to be equipped with an earth hole at each end for earth strap connections
- All cable ladders shall be bonded across all joints and sections to maintain electrical continuity.
- All cable ladders shall be bonded to the equipotential earthing system as per the requirements of this specification

Cable ladder routes shall be selected as follows:

- Cables routes shall be incorporated into pipe racks where practical.
    - The routing of other services including pipes for compressed air or water on cable ladders is not permitted
    - It is not acceptable to run process pipework on cable ladders
- Generally, cable ladders shall be installed with rungs horizontal at the locations and levels detailed on the project drawings
- Significant cable ladder clashes or route deviations shall be resolved in conjunction with Urban Utilities
- Cable ladders shall not interfere with access to equipment or passageways
- Cable ladder routes shall not subject the cables to excessive heat or the possibility of mechanical damage resulting from adjacent services or equipment
- Ladders shall be run true, straight and squared with the structure and follow the natural line of the structure
- As far as practical all cable ladder runs are to be continuous with bends, risers and reducers used for change of directions or change of ladder sizes
- Ladders shall run in parallel or perpendicular directions only - diagonal or sloping sections shall not be used

- Cable ladder shall be installed to maintain a minimum head clearance of 2200mm in walkways. All cable ladders shall be installed to allow unimpeded access to one side of the ladder
- In addition to the cable ladders detailed in Project Documentation, the works shall include the installation of all cable ladders required to reticulate cables from the main ladder routes detailed on the drawings to the final device/equipment locations
- Cable ladder routes running over grass or other vegetation shall leave sufficient ground clearance to allow mowing and clearing of the vegetation without damaging the ladder

Perforated cable trays as a substitute for cable ladder is not permitted unless accepted under special circumstances by Urban Utilities.

Cables to final devices shall be provided with heavy duty mechanical protection where they leave cable ladders, typically using heavy duty flexible conduit.

PVC corrugated and flexible conduits (medium or light duty) are not accepted as adequate mechanical protection.

5.4.16.3 Above-Ground Conduit

Cable routes above-ground shall be run in cable ladder, with conduit being used for final runs only. Rigid conduits shall be in accordance with AS/NZS 2053. Flexible conduit shall be heavy duty and non-metallic. PVC corrugated conduits shall not be used.

Installation requirements for conduits used above-ground are summarised below:

Application	Accepted conduit types
Process & field equipment	Heavy duty flexible, if additional mechanical protection is provided (e.g. run through Unistrut channel or similar) where route exceeds 600mm. Final exposed length of conduit to the end equipment shall not exceed 600mm. Rigid metallic conduit, if connected to the equipotential bonding system Heavy duty rigid PVC (painted). Use of heavy-duty rigid conduit for above-ground cable routes (excluding stub-ups) is subject to approval.
Lighting, building services and security equipment	All accepted conduits for process & field equipment Medium duty rigid PVC where conduit is not exposed to the risk of mechanical damage (e.g. indoors, non-trafficable areas, ceilings ≥2200mm above floor level)

For all changes in direction, draw boxes shall be installed or large sweeping bends fabricated to suit the minimum bending radii of the cables to be installed. Offsets and bends shall be uniform and symmetrical. All bends shall be made without kinking or destroying the circular cross-sectional profile of the conduit. "Elbow" and "Tee" fittings shall not be used unless otherwise accepted.

The minimum size of surface conduit permitted throughout the installation shall be 20mm.

In applications where the conduit is to be installed strictly for mechanical protection of the cable it shall be acceptable for the conduit runs to be discontinuous. However, unprotected cable sections shall be minimised and located only where the unprotected cable is not exposed to the risk of mechanical damage. All conduit ends shall be de-burred, smoothed and finished with some means of cable protection (knock-on, threaded bush or similar) and shall be sealed to prevent the ingress of moisture and material after the cable installation has been completed.

In applications where the conduit is to be installed to provide UV protection, weatherproof protection or EMC protection of the cable the conduit run shall be continuous.

Unless otherwise specified, double sided saddles or proprietary conduit clamps and channel shall be used for fixing of all conduits. All conduits regardless of the length shall be fixed using conduit support brackets.

Surface conduit runs shall be installed true, straight and squared with structural lines and shall follow the natural lines of the building or structure.

Conduits, unless accepted otherwise by the Urban Utilities, shall be provided with a draw wire.

In special applications flexible steel conduit may be installed. In such instances both the application and the flexible conduit shall be accepted by Urban Utilities prior to installation. All flexible steel conduits shall have an outer PVC sheath.

Conduit runs shall be cleaned and swabbed to remove foreign matter and moisture prior to pulling in wire or cable.

Where conduits are to be installed between a hazardous and non-hazardous area, the conduit end in the hazardous area shall be sealed to prevent the propagation of gas. Installation requirements are outlined in Section 5.13 Hazardous Area Installation.

Conduits, both flexible and rigid, installed outside shall be sealed or installed to prevent to accumulation of water and entry of water entry into junction boxes and equipment.

5.4.17 Underground Cables

5.4.17.1 General

Power, control, instrumentation and communications cables installed underground shall be run in heavy-duty conduit.

Direct burial of cables is prohibited unless accepted in writing by Urban Utilities.

Urban Utilities shall be advised of the following stages of installation:

- When trenches have been excavated and bedding material laid in readiness for conduit installation
- When conduits have been laid in trenches prior to backfilling
- When mechanical protection (e.g. concrete slabs) have been laid over the trenches, prior to final backfilling
- When a HV cable joint is to commence
- Prior to all testing of cable so Urban Utilities may witness the test

The exact details of the testing for underground cabling shall be defined in the relevant Inspection and Test Plan (to be accepted by Urban Utilities) and shall include as a minimum cable drum testing and post-pulling cable testing for all underground cables.

Where required in the relevant ITPs, digital photos of underground cable routes shall be provided to clearly show pits, penetrations, bends, depth, bedding and other important aspects of the installation.

Prior to the backfilling of cable trenches, the trench shall be surveyed for future reference and marked up on the relevant drawings detailing the "as installed" route and the locations of the pits and cable markers.

The location of the trench shall be referenced back to fixed structures or relevant survey coordinates defined.

Where existing or proposed cables, pipes or sewers intrude into or pass over the route, the trench shall be excavated to enable a crossing to be completed that maintains both required segregation distances between services and depth of cover for electrical services.

Buried earth grids shall not require bedding material or polymeric protection covers but shall include cable warning tape.

5.4.17.2 Cable Separation from Underground Services

Cables installed in Urban Utilities facilities shall maintain minimum separation distances from underground services in accordance with AS/NZS 3000, as follows:

Type of Service	Size	Min. Separation to LV Electrical Service (mm)	Min. Separation to LV Electrical Earthing Electrode (mm)
Water Services	> DN65	300	500
	≤ DN65	100	500
Sanitary drainage	All	100	500
Stormwater drainage	All	100	600
Gas	All	100	500
Telecommunications	All	100	-

HV electrical services shall maintain a minimum separation distance of 300mm from all underground water, drainage, gas and telecommunication services.

Underground cables installed within the network shall maintain the clearances outlined in the SEQ Code.

5.4.17.3 Underground Conduits

The following requirements shall apply regarding conduit:

- Underground conduits shall be heavy duty rigid PVC in accordance with AS/NZS 2053 and shall be bedded in sand (or similar accepted bedding material).
- Corrugated underground conduits of any type are not acceptable, including those with internal smooth bores such as “Corflo”
- Sandwich construction conduits are not acceptable
- Underground conduits shall have a minimum size of 50mm

The following requirements shall apply regarding conduit colour:

- Conduits shall be coloured orange for all electrical applications such as HV, LV, ELV and control cables.
- Telecommunications conduits shall be preferably white (if available in heavy duty rigid PVC), otherwise orange with white stripe is acceptable. Austel type medium duty white telecommunications conduit is not acceptable.

The following requirements shall apply regarding construction design considerations:

- To ease cable pulling, individual conduits shall not be filled to more than 80% of their theoretical capacity as per AS/NZS 3000 Appendix C
- A minimum of 25% spare number of conduits must be made available after completion of the designed works, except when approved in writing by Urban Utilities
- Separate conduits are required for
    - HV power cables
    - LV power cables
    - ELV power & control cables, instrumentation cables
    - Communications cables
    - Intrinsically Safe cables

The following requirements shall apply regarding conduit routes:

- Cable trenches and conduits shall be straight and even throughout their entire route.
- Unless specified otherwise, cable draw pits shall be spaced a maximum of 50 metres apart and at all changes in direction for underground conduit runs.
- Generally, changes in direction shall be completed using cable pits. However, with approval from Urban Utilities large sweeping conduit bends up to 45 degrees shall be acceptable provided that the bends are sized to suit the minimum bending radii of the cables to be installed.
- Conduits shall be located not less than 2 metres behind the kerb line or shoulder where applicable except where shown on the drawings.

The following requirements shall apply regarding stub ups:

- Cables leaving the ground shall be mechanically protected by heavy duty flexible conduit, heavy-duty rigid PVC conduit or an aluminium top hat section for transition to cable ladder
- Conduit shall be secured in position, extending from 400mm below ground level to a minimum height of 100mm above ground
- Rigid PVC conduit used for this purpose shall be treated for exposure to direct sunlight or be painted.
- Each conduit shall either stub up directly into or below the equipment to be connected
- Conduit stub-ups, entries into cable pits or underground terminations (i.e. road crossings) shall be sealed after the installation of cables to prevent the ingress of water and other materials
- This sealant shall be a non-deteriorating, non-setting weatherproof sealant capable of being removed for future cable installation
- The positioning of the stub up shall be verified as correct before pouring of concrete

The following requirements shall apply regarding assembly of conduit systems:

- All underground conduit runs shall be continuous with all joints completed using conduit bell ends (or couplings) and PVC conduit joining compound as per the supplier's recommendations
- All conduits unless otherwise specified shall be provided with a cable draw wire. A 3-core polyethylene or polypropylene rope, with 5.0 mm nominal diameter and orange or yellow in colour, shall be installed in each conduit and suitably anchored at each end.
- Conduits shall be capped at each end prior to installation to prevent foreign material entering the conduit. Special care shall always be taken to ensure that all conduits are free of foreign material

The following requirements shall apply regarding laying of conduit in trenches

- All underground conduits shall be installed on and covered with a layer of accepted bedding material. This material shall be:
    - Clean
    - Consistent
    - Friable
    - Free of large and/or sharp materials (e.g. stone)
    - Free of chemically active material
    - Compacted in the trench
    - Have depth and volume as per relevant underground cable cross-sectional drawings
        - Minimum layer of 50mm depth underneath the conduits
        - Minimum of 50mm bedding material between the conduits and the edge of the trench
        - Minimum layer of 50mm depth on top of the conduits

    - Tested to confirm material properties (i.e. thermal resistivity & moisture levels) are suitable for the application as detailed in relevant Project Documentation
- The trench shall be backfilled with a good quality clean fill.
    - Both the bedding material and clean backfill shall be accepted by Urban Utilities before use
- All conduits shall be installed at a depth not less than 600mm below the finished ground surface level (unless under concrete - refer to AS/NZS 3000 for guidance). Concrete shall not be laid solely for the purpose of reducing cable depth.
- A continuous strip(s) of 150mm wide orange PVC marker tape shall be laid above all buried conduits. The marker tape shall be:
    - In accordance with AS/NZS 2648.1
    - Multiple parallel runs of marker tape shall be used where required to cover the full width of the trench and shall extend a minimum of 40mm on either side of the conduits
    - The marker tape shall overlap for 2m at the ends of consecutive strips
- Conduits located in areas such that the gradient of the intended installation may stress or cause movement of the conduits, shall incorporate the following additional provisions as accepted by Urban Utilities:
    - Suitable measures to prevent the bedding and backfill materials from washing-out during heavy rain events;
    - Suitable measures to prevent excessive weight bearing on the conduit

The following requirements shall apply regarding conduits in road crossings:

- Where conduits are to pass under roads, railway lines, equipment or structure foundations, additional mechanical protection shall be provided to protect conduits from the loads that will transition over the cable routes.
- Standard installation drawings for underground cables shall detail the typical arrangement for underground road crossings, including clearances and cross sections. In all instances, an additional means of mechanical protection shall be provided in the form of one or more of the following:
    - Additional installation depth
    - Use of concrete encased conduits (or similar)
    - Use of pre-cast concrete covers
    - Use of heavy-duty steel or concrete conduits (or similar)
- All road crossings shall be equipped with spare (empty) conduits for future

5.4.17.4 Cable Pits

In all instances cable pits and covers shall be traffic rated to suit the application. The traffic rating shall be defined in Project Documentation or as directed by Urban Utilities. For cable pits used for road crossings the pits shall be traffic rated to at least that of the traffic on the road.

The following table provides guidance regarding minimum load classes for cable pits and covers:

Traffic Description	Examples	Min. AS 3996 Load Class
Non-trafficable Areas	Footpaths not accessible by vehicles	A
Very low speed Occasional traffic Transient light vehicle loads or large equipment on trolleys	Vehicle accessible footpaths or plant areas Driveways	B
Low speed Intermittent traffic Persistent light vehicle loads	Residential & minor roads	C
High Speed Consistent traffic Transient heavy vehicle loads	Major roads Highway shoulders (not for highway crossings) Warehouses, laydown yards & loading docks Treatment plant roads, water and sewage pump station roads and facility carparks	D

The following design requirements are applicable to cable pits:

- Cable pits shall be provided at all changes of direction for underground cables
    - With approval from Urban Utilities large sweeping conduit bends up to 45 degrees may be acceptable provided that the bends are sized to suit the minimum bending radii of the cables to be installed.
- The maximum distance between cable pits shall be 50m
- Cable pits shall be provided on either side of any road crossing
- Cable pits shall be sized to allow the installation of cables without exceeding the cable bending radius
- Cable pits shall be sized to maintain the necessary segregation between different electrical services if sharing a common pit
- Cable pits shall have sufficient depth to ensure the lowest conduit entering the pit leaves 100mm clearance at the bottom of the pit
- Cable pits shall have sufficient depth to allow conduits to enter pits level and at their required depth of cover
- Cable pits shall be equipped with suitable drainage (as defined by Urban Utilities) which shall be in the form of a separate soak well or similar for large cable pits
- Class D pits larger than 1200mm x 1200mm shall be cast in-situ

Cast in-situ pits shall conform to the following additional requirements:

- Pit shall be structurally designed cast in-situ concrete
- Facility shall be provided for earthing the re-enforcement steelwork (re-bar)
- Bell ends shall be cast into the pit walls to facilitate the conduit entries

Pit covers shall conform with the following:

- Pit cover shall have weight of cover indicated
- Pits exceeding 600mm x 600mm shall have split covers
- Steel pit covers shall be greased with manufacturers recommended lubricant
- Lids shall be fitted with suitable facility for lifting
- Suitable supports shall be provided to ensure the lid cannot fall into the cable pit
- Pits shall be orientated so the covers can be safely removed

The following installation requirements apply:

- In non-paved areas, the top of each pit shall be above the design surface level or natural level by 50mm +/- 10mm with the localised soil within 1 metre graded up to the top of the pit.
- When installed in paved areas, pit lids shall be at the same level as the surrounding pavement surface.
- Pits that are installed in other than paved areas (concrete or bitumen) shall have 150mm concrete mowing strips installed around the pit.
- Where conduits enter pits
    - A clearance hole (-0 +5mm) to suit the conduit size shall be cut in the pit using a hole cutter or similar tool.
    - Pits with holes knocked in with a hammer or similar tool shall be rejected
    - Only one hole for each conduit entering the box shall be cut
    - The bottom of cable conduits entering cable pits shall enter at no less than 100mm from the bottom of the cable pit. This is to ensure that debris or silt that may settle on the pit bottom does not enter the conduits.
    - Adjacent conduits entering a pit shall have no less than 50mm clearance from each other
    - Conduits entering a pit shall have no less than 50mm clearance to the edge of the pit wall
    - Conduit shall be sealed to the pit with Sika-Flex construction Polyurethane Joint Sealant or similar accepted sealant
- All foreign material including sand and dirt shall be removed from the pit after installation
- At the conclusion of works and before hand over to Urban Utilities, accepted rodent control measures shall be employed in all pits (e.g. poisonous rat baits)

5.4.17.5 Cable Trenches

Prior to the commencement of cable trench excavation all relevant permits and approvals shall be attained and all existing in-ground services identified as per the project site requirements. In areas where exact location of underground services

cannot be located or as directed by Urban Utilities, water blasting at maximum 2000kPa pressure shall be used to locate underground services.

Excavation works shall be planned to minimise disruption to the day-to-day operations of the site, to minimise the period that excavations remain open and minimise the length of open trench at any one time.

Excavation and backfilling activities shall adhere to the requirements detailed in the EMP, especially requirements relating to general soil management and subsoil management.

In all instances the excavation equipment shall be selected to suit the application. Particular attention shall be given to the size of the excavation equipment with respect to the trench size and the suitability of the excavation equipment for the works location.

Trenches shall be excavated to accommodate the conduits, spacing/segregation, bedding materials and other materials required to complete the installation. The depth of the excavation shall be sufficient to ensure that the minimum statutory and project cover between the uppermost cable and ground surface is maintained for the entire length of the trench. Finished ground level for the areas to be excavated shall be ascertained on site prior to trench excavation.

Trenches shall be cut squarely and the bottom shall be flat and free from stones or hard projections. Trenches shall be cordoned off with protective barricades and shall be maintained clean and free of water, collapsed wall material and foreign materials. Trenches of depth greater than 1.5 metres (or in accordance with the requirements of the project safety procedures) shall be shored, benched, shielded or similar to mitigate/manage the risk of trench collapse to personnel working within the trench.

Trenches shall be excavated to an adequate depth to provide the following minimum cover over the cable or underground conduit/duct:

Installation	Depth of Cover
Bare earth cables	500mm
LV cables with active conductors	600mm
HV cables	750mm
All cables below road crossings (LV and HV)	750mm

Trenches to be excavated to a depth greater than 1300mm shall be accepted by Urban Utilities prior to commencing works.

Paving, drainage, road surface or similar disturbed by trenching shall be reinstated to the original condition.

Backfilling and compaction (including compaction levels) of trenches including the re-instatement of the finished surface shall be in accordance with the requirements of Project Documentation.

Trenches shall be backfilled as soon as practicable after laying cables/ducts. During backfilling, subsoils should be re-instated in the same order as excavated where

practicable, particularly where salinity and/or sodicity increase at depth. The subsoil shall be reinstated to the same subsoil level as surrounding soils, and the original profile of topsoil shall be reinstated.

Excavations not in paths or roadway shall be backfilled and compacted to match the surrounding soil density and graded to match surrounding surface level. The top 100mm layer above the top of the conduits shall be sand and the surface finished off in the existing surrounding surface.

Surplus material and spoil remaining after completion of the backfilling shall be removed and disposed of as directed by Urban Utilities and in accordance with the EMP or stockpiled for future site rehabilitation as directed by Urban Utilities.

Excavations in proximity to paved areas shall be suitably shored to prevent the sides of the excavation from collapsing. Paved areas shall not be undermined by excavations. Any damage caused to paving and other structures due to excavation activities shall be repaired prior to completion.

Pavement surfaces, including turf, concrete or brick paved areas and pathways, shall be reinstated prior to completion.

5.4.17.6 Cable Route Markers

Routes of underground power and control cables shall be identified using clearly visible above ground cable route markers.

Cable route markers shall indicate the direction of cables in the ground and shall be installed where defined in Project Documentation and at the following locations:

- At road reserve boundaries on either side of road crossings
- At foreign service easement boundaries on either side of foreign services crossings
- At banks/high points on either side of significant water course crossings
- At each end of the route
- At all changes of route direction
- At the below listed maximum intervals in-between
    - within facility perimeter fence lines - 50 metres
    - outside facility perimeter fence lines - 100 metres

In any case route markers shall be sized, spaced and located to ensure that each cable route marker shall be visible with the human eye from the adjacent before and after markers.

Cable route markers shall be constructed and installed to a standard installation drawing accepted by Urban Utilities.

Cable route marker shall be adhesively attached to a post or bollard.

- Typical posts for this purpose are 76 x 38 x 2 RHS, 1300mm long and finished in Matt Golden Yellow Y14 in accordance with AS 1743, with a yellow cap inserted into the top of the post.

The post or bollard shall be of durable materials of either UV resistant heavy-duty plastic or aluminium.

Optionally, cable route marker plinths at ground level are acceptable for in-plant cabling only. Markers shall comprise engraved stainless markers embedded in concrete plinths. Markers shall be placed at the following locations:

- The end of each route (i.e. entering buildings, at fences etc.)
- At each change of direction (i.e. visibly indicating entry into pits)
- At maximum intervals of 25 metres (i.e. halfway between two pits on a straight run)

Detailed locations and marker plinth design to be accepted by Urban Utilities.

5.4.17.7 Underground Cable Ducts

Underground cable ducts shall be structurally designed to suit the application.

The configuration shall ensure adequate working space as well as safe access and egress for the construction works and any future cable repair works.

A suitable drainage system shall be incorporated into the duct system.

Typically, cable ladders shall be utilised for the reticulation of cables within cable ducts.

Cable ladders shall be installed a minimum of 150mm clear of the floor level to ensure cables are kept clean and dry.

Cable duct shall be designed to facilitate the installation of cable ladder support systems via cast-in channels (or similar) or shall be suitable for the installation of drilled masonry fixings.

Cable duct design shall incorporate cable penetrations that can be adequately sealed upon completion of the installation.

5.4.17.8 Cast In-Situ Conduit

Unless specified otherwise, conduit to be cast into concrete shall be heavy duty rigid PVC in accordance with AS/NZS 2053.

Cast-in-situ conduit runs shall be continuous with all joints completed using conduit bell ends (or couplings) and PVC conduit joining compound as per the suppliers' recommendations. "Elbow" and "Tee" fittings shall not be used unless otherwise accepted.

For all changes in direction draw boxes or large sweeping bends shall be installed. The minimum size of conduit permitted throughout the installation shall be 25mm. Conduits shall be suitably sized and the number of bends kept to a minimum to facilitate cable installation.

Conduits and fittings shall be adequately fixed to the reinforcement steel or formwork to ensure the installation can withstand the rigors of a concrete pour.

Conduits, unless accepted otherwise by Urban Utilities, shall be provided with a draw wire. Once cables have been installed (or for spare conduits) both ends of the conduits shall be sealed to prevent the ingress of water, vermin and materials. This sealant shall

be a non-deteriorating, non- setting weatherproof sealant capable of being removed for future cable installation.

Generally conduits shall stub up either directly below or adjacent to the equipment to be connected. Positioning of the stub up shall be verified as correct before pouring of concrete. The stub ups shall project 100mm above finished floor/ground level.

In all instances where conduits are to be installed between a hazardous and non-hazardous area, the conduit end in the hazardous area shall be sealed to prevent the propagation of gas. Refer to Section 5.13 Hazardous Area Installation for detailed installation requirements.

5.4.17.9 Horizontal Directional Drilling

For Horizontal Directional Drilling (HDD) cable crossing installations, all engineering analysis, specification of appropriate plant, temporary works design, design of installation aids, and detailed calculations to facilitate construction of the works shall be carried out. Engineering design shall be accepted by Urban Utilities and where necessary, by the owner of the structure being crossed before drilling operations commence.

Where HDD works are required, these shall include but not be limited to the following activities:

- Detailed HDD design
- Validation of detailed HDD design
- HDD drilling and site set-up
- Cable installation and testing
- Post installation integrity test

As part of the HDD engineering design work, the following shall apply:

- Installation related loads on the cables when being pulled through the HDD holes which have not been considered in any preliminary design. These shall be calculated and accepted by the certification engineer
- Any preliminary HDD profiles and cross-sections developed by Urban Utilities shall be reviewed and altered as deemed necessary to ensure the technical feasibility of installing the cables within the HDD holes
- The specifications of the drilling fluid shall be accepted by the certification engineer. Compliance with government regulations and permits shall be confirmed

In the event of any leakage or spillage of drilling fluids they shall be contained within suitable bunds. Fluids shall be disposed of in accordance with the EMP in line with the Land Release Management Plan requirements.

Spoil or waste material generated shall be disposed of in accordance with the EMP.

5.4.18 Assessment and Reuse of Existing Cables

It may be advantageous in certain situations to re-use existing cables for new equipment rather than replace with new (e.g. when endpoint equipment is replaced

with new equipment of similar duty at the same location). When cable reuse is proposed and defined in Project Documentation, a cable condition assessment shall be carried out during the investigation phase to determine that the cables proposed for reuse are fit for the intended purpose.

The performance criteria for the cable condition assessment shall be as defined in Project Documentation or as agreed with Urban Utilities.

The cable inspection report shall be subject to review and acceptance by Urban Utilities, only cables accepted by Urban Utilities for reuse shall be retained, cables shall ensure the service life of the installation is in accordance with Project Documentation.

Existing single insulated wiring, if disturbed, (particularly in plant areas) shall be replaced with double insulated cables. When out-of-scope single-insulated wiring is identified, it shall be brought to the attention of the Urban Utilities.

5.5 Ethernet and Fibre Optic Cabling

5.5.1 Ethernet Cabling

Category 6A (Cat6a) Ethernet copper communication cabling (designed for transmission frequency to 500 MHz) shall be used to connect Ethernet capable devices located indoors (e.g. within switchrooms, switchboards, PLC enclosures and network cabinets).

a) Distances for Cat6a cable shall not exceed 90 metres total in route length, including patch and fly leads.
    i. Cable routes external to buildings shall, for their entire length, be:
        i. As short as possible
        ii. Mechanically protected
        iii. Protected from vermin
    ii. Ethernet cable shall not be used to connect two switches located in separate rooms or buildings.
    iii. Ethernet cable shall not be used to directly connect any two PLCs or RTUs
    iv. Ethernet cable shall be suitably rated for its intended installation. Selection shall consider environmental conditions (UV, moisture, heat). Ethernet cable used underground or outdoors shall be rated for this purpose.
b) Cat6a cables shall be plenum rated (i.e. fire resistant) at a minimum and teflon coated
c) Riser (i.e. jacketed) cable shall be used between floors of any building housing offices or amenities
d) Standard RJ45 quick connectors shall be provided to connect to LAN devices.
e) RJ45 connectors shall meet class E characteristics.
f) Supplier approved cable and cable connectors shall be used for fabricating Ethernet patch cables. The UTP cables shall have moulded snagless boots, unless otherwise specified.
g) Patch cables shall only be installed within cabinets and shall not bridge equipment or cubicles, unless otherwise accepted.

h) A site certification for installation and supply of UTP cables and associated equipment shall be provided and included in final documentation.
i) The communications rack supplied shall have dimensions to accommodate the minimum bending radius of Cat6a cabling. To accommodate this, the rack shall provide extra deep horizontal cable managers (e.g. for Panduit) and provisions for vertical cable management.
j) Ethernet cables installed for outdoor applications i.e. outside the buildings shall be UV sunlight resistant.
k) Ethernet cables shall be individually glanded into each cubicle, cabinet, panel or equipment.
l) Ethernet cables where installed in LV or HV switchboards shall be industrial grade with the following specifications:
    i. Shall utilise bonded pair technology
    ii. Shall be shielded
    iii. Shall contain solid conductors
    iv. Installation stress resistant
    v. Shall contain industrial grade jacket

Security and CCTV Ethernet cables shall be labelled at the patch board with text "SECURITY SYSTEM DO NOT DISCONNECT". See TMS 117 *Specification for Security, Access Control & CCTVCCT Systems* for specific requirements related to Security and CCTV Ethernet cables.

The requirement of colour code for Ethernet cabling is listed in the below table:

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

5.5.2 Fibre Optic Cabling

In this section:

- In-plant cables refer to cables installed and connected end to end within a site fence boundary.
- Out-of-plant cables refers to cables installed between sites, typically over longer distances and with routes in publicly accessible areas.

The fibre optic cables installed in duct, external tray, pits or direct buried shall comply with the following requirements as a minimum;

a) Unless otherwise specified, for all out-of-plant control systems networks (SCADA & WAN), fibre optic cabling shall be 9/125 µm (OS2) single mode glass fibre type cable.

b) Single mode fibre-optic cabling design shall provide sufficient bandwidth to support 1 gigabit communication.
c) For all in-plant control systems networks and patch leads (Remote I/O LAN, PLC LAN, SCADA LAN), fibre optic cabling shall be 50/125 µm (OM2) multi-mode glass fibre type cable
d) Fibre cables and terminations shall be physically separate for the different applications (Control network, building security, CCTV, SCADA WAN etc.)
e) Fibre optic cabling shall be installed with the following minimum clearances if not installed within conduits or mechanically separated in cable ladder:
    i. 150mm from Piping
    ii. 50mm from LV Electrical Cabling
    iii. 50mm from HV Electrical Cabling

Fibre optic cables shall have the following construction and features:

a) Complete non-metallic loose tube construction
b) Tubes shall be gel-filled to prevent ingress and axial migration of water, strengthened with flexible non-metallic armour bonded to the inner polyethylene sheath
c) Fibres and tubes shall be colour coded
d) An outer protective jacket (nylon or polyurethane) and sacrificial sheath to protect the smooth, hard nylon jacket from being damaged during installation
e) A strain bearing, non-metallic member
f) For in-plant cables and regardless of installation method (duct, external tray, pits or conduits) the cable supplied shall offer non-metallic insect and rodent resistant armour
g) Surface printing includes marking at 1-metre intervals
h) Sufficient spare cable shall be left at both termination ends to allow for removal and re-termination of the FOBOT at a good working height without risk of damaging the cable.
i) Fibre Optic cabling shall be installed in separate cable ladder, segregated cable ladder, or conduits and in accordance with CA (Communications Alliance) S009 *Installation requirements for Customer Cabling*
j) Site based underground fibre optic cabling shall be installed in separate underground conduits and secured to the side of cabling pits with additional protective covers or conduit to prevent possible damage
k) Fibre optic cabling shall be designed in a ring topology for Class 2 & Class 3 architectures as per requirements specified in TMS1733 *Control Systems General Specification*. Fibres forming each part of the ring shall be in separate fibre cables, not cores in the same cable. The network shall be configured so that any single fault in the fibre network shall not result in loss of communication
l) Fibre cables shall provide a minimum of 25% spare core capacity (or four (4) spare cores, whichever is greater) in all fibre cables installations
m) Fibre optic devices shall use pre-manufactured fibre patch leads for the connections to the patch panels
n) Fibre connectors shall be LC type for new installations and patch leads
o) In-plant patch leads shall be ruggedized military specification (mil spec) type where required to transition outside of an electrical enclosure

p) Fibre patch leads and in-plant fibres cables shall be glanded on entries to equipment and cubicles
q) Underground fibre optic cable shall include spare length at every second pit. Minimum 50mm conduit shall be used for underground installation of fibre optic cables
r) 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
s) The specifications for all fibre optic cables shall be submitted to the Urban Utilities for final approval prior to procurement of the cabling

5.5.2.1 Out-of-Plant Buried Installation of Fibre Optic Cables

Single mode optical fibre used for either SCADA or WAN applications or fibre optic cables installed between two sites shall be a water blocked single loose tube non-metallic cable designed for long haul applications. These fibre optic cables shall be suitable for external cable ladder, duct and installation in conduit.

The minimum requirements of installation for the underground fibre optic cable shall be:

a) Cables to be installed in heavy duty conduit
a) Minimum depth of cover shall be 600mm
b) Cable sheath shall be rodent and termite resistant
c) Provide a minimum 100m wide warning tape, 300mm above the conduits / buried cable. The warning tape shall be marked “Danger – Buried Communication Cable Below” and include a 316 stainless steel tracer wire to enable detection of the fibre optic cable route along the entire length

5.5.2.2 Fibre Optic Cables Installation in Pits

Cable pits shall be adequately sized to allow for fibre optic cable bending radius and service loops.

The fibre optic cable is to be installed in one continuous length to avoid splicing in cable pits.

Fibre optic cables shall be kept clear of power cables (minimum 50mm from LV electrical cables & 300mm from HV electrical cables) in pits to maintain clear access to the power cables and for jointing work on the power cables. This includes avoiding the creation of restrictions to access to the pit, such as cables being passed too close to access ladders.

5.5.2.3 Fibre Testing

All fibre cores shall be tested after installation as per requirements specified in Communications Cabling Manual (CCM) Volume 2 - 2007. Test sheets shall be submitted to Urban Utilities for acceptance. Test results shall include the following as a minimum:

a) Details of test instruments and method used for fibre testing
b) Date of testing

c) Identification number for cables, fibres and fibre cores
d) Measured length of fibres
e) Loss in dB

5.5.2.4 FOBOTs

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

Spare capacity requirements for FOBOTs are as follows:

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

Construction requirements for FOBOTs are as follows:

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

Termination requirements are as follows:

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

FOBOTs shall meet the following requirements for cable management:

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

FOBOTs shall be located as follows:

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

The following labelling requirements apply:

- FOBOTs shall be assigned unique equipment tag numbers as per TMS1647 *Plant and Equipment Tag Numbering* and visibly labelled with a traffolyte label.

- A label "WARNING: FIBRE OPTIC CABLE" with black text on a yellow background shall be prominently affixed to each FOBOT
    - This may be a sticker when the FOBOT is inside a control or communications panel

Otherwise, labels shall be laminated traffolyte with slotted holes, attached to the equipment where appropriate via stainless stainless-steel screws or bolts.

5.6 Serial Communication and Fieldbus Cabling

Fieldbus cabling shall be routed directly between fieldbus cards, fieldbus junction boxes and end devices.

Fieldbus cables shall not to be terminated on intermediate terminals.

Equipment such as meters, motor protection relays, circuit breakers and the like which are specified to be part of a serial communications link (whether copper or fibre) shall have communication wiring installed as per the manufacturer's instructions, using the manufacturer's proprietary connectors and cables.

Serial cabling shall be installed in accordance with industry best practice installation guidelines and to reduce EMC disturbances.

5.7 Protective Earthing and Lightning Protection

5.7.1 Earthing System Overview

Earthing works shall be compliant with AS/NZS 3000 and the associated purpose specific directives detailed in Project Documentation. The works associated with cathodic protection are not detailed in this section and shall be included elsewhere.

Buried bare copper grading rings shall be installed around the perimeter of the plant areas. Additionally, buried mesh-type earthing grids shall be installed within the facilities at all significant plant that may be subject to substantial fault levels (i.e. switchrooms, transformers, large packaged plant).

A main earth bar (MEB) shall be provided within the electrical substation at each facility. A switchroom earth bar shall be provided for each switch room and shall be utilised for the equipotential bonding of equipment within the switchroom. Each switchboard/MCC/distribution board/UPS within the switch room shall be equipped with an integral earth bar that shall be bonded to the switchroom earth bar.

A transformer earth bar shall be provided for each transformer compound and shall be utilised for the equipotential bonding of equipment within the transformer compound. The switchroom and transformer earth bars shall be bonded to the facility MEB via PVC insulated earth cables installed in cable ladder.

An equipotential earthing loop shall be installed throughout the plant area. This earthing loop shall be used for equipotential bonding of the equipment and structure throughout the plant and conform to the following requirements:

- Cable shall consist of a 25mm^2 (minimum) to 120mm^2 PVC earth cable
- Cable shall start and finish at the substation main earth bar
- Cable shall be run throughout the plant on the power cable ladder system
- The cable shall be sized such that it could be relied upon on to keep touch potentials in the cable ladder system below unsafe levels without reference to any other paths to earth (including individual circuit earth conductors or the continuity of the cable ladder system itself)

At locations of high density electrical equipment (i.e. equipment skids) dedicated field earth bars shall be provided for earthing equipment within the area.

A direct earthing system shall be used for the LV distribution at all facilities. Neutral points at the low voltage transformer windings shall be solidly earthed (typically via an MEN link located in the main LV distribution switchboard) or where not detailed shall be earthed to the transformer earth bar.

Non-current carrying metallic parts and enclosures of electrical equipment and metallic structures used for mounting electrical equipment shall be effectively bonded to earth throughout the plant so as to ensure that all exposed conductive parts are at substantially equal potential during normal operation and under fault conditions. Exposed conductive parts of equipment, piping, vessels and structural items in hazardous areas shall be effectively bonded to prevent the accumulation of static charge and for lightning protection.

5.7.2 Equipotential Earthing

Buried earth grids shall utilise radial taps for bonding to the following:

- significant equipment (motors, tanks, vessels, etc)
- structural steelwork
- reinforcing steelwork in the concrete footings
- field earth bars
- fences and gates

The equipotential earth loop cable that runs throughout the plant on the cable ladder system shall utilise radial taps for bonding to the following:

- significant equipment (motors, tanks, vessels, etc)
- structural steelwork
- cable ladder
- field earth bars

Earthing standard installation drawings shall detail the arrangement of these bonds.

The ends of each full length of cable ladder and cable ladder fittings shall be supplied with an earthing hole for earth bonding connections.

Motors, process tanks and vessels and transformer tanks shall be supplied with suitable earthing lugs/bosses and shall not be welded or modified on-site to facilitate earth bonding unless accepted by Urban Utilities.

5.7.3 Buried Earth Grids and Grading Rings

The buried earthing grids and grading rings shall consist of a series of buried earth electrodes interconnected using bare 120mm^2 copper earth cable, installed at a depth of 0.5m below finished ground level.

Buried earth grid connections shall be exothermically welded (Cadweld) or made by Urban Utilities accepted “C” compression connectors. Refer Section 5.7.7 Earth Connections.

Buried bare copper earth grid cables shall be provided with orange PVC cable warning tape (in accordance with AS/NZS 2648.1) buried over the top of the bare copper cable at approximately 300mm below finished ground level.

The finished ground level shall be ascertained on site prior to the commencement of the installation of buried earthing grids.

Scheduling and coordination of the Works shall ensure suitable access and to minimise the risk of damage to the earth grid during the construction works (i.e. from earth works, foundation works and heavy construction plant). Earth electrodes/pits shall be provided with temporary barricades and high-visibility flags to prevent damage during construction works.

Buried earthing grids that sustain damage during the construction works shall be repaired using suitable equipment, components and procedures to ensure the integrity of the earth grid is not compromised. Earth grid repairs shall be tested to satisfaction of Urban Utilities to verify the integrity of the repaired buried grid.

5.7.4 Earth Electrodes

Earth electrodes shall be steel core rods with an electrolytic coating of copper deposited over a layer of nickel (i.e. Eritech copper-bonded earth rods or accepted equivalent). Electrodes shall be a minimum 17mm diameter, provided in minimum extension lengths of 2400mm and shall be extendable via threaded couplings.

Tails shall be used to bond electrodes to buried earth grids will be detailed in the installation drawings. This configuration shall enable the electrode to be disconnected from the buried grid for testing without disconnecting the buried earth grid loop. These tails shall be bonded to the buried earth grid via exothermic (Cadweld) connections or Urban Utilities accepted “C” compression connectors.

Connections to electrodes shall be completed using proprietary purpose designed earth rod clamps and shall be primed and wrapped using Denso tape and primer (or similar) to protect the integrity of the connection from the elements.

Earth electrodes shall be protected with an inspection pit of minimum traffic load class C (in accordance with AS 3996) that shall provide suitable access to the electrode for testing purposes. All earth pits shall be clearly labelled. The label shall include the words "Earth Electrode" (or similar) and shall also include the unique electrode identification number as defined in Project Documentation.

A suitable electrode numbering convention shall be nominated for Urban Utilities acceptance where electrode tag numbers have not been assigned in Project Documentation.

Where holes are to be drilled to facilitate the installation of the electrode rod, the hole shall be back- filled with a suitable earth enhancement compound (ERICO "GEM" or equivalent). The mixture shall be thoroughly mixed, formed into a slurry and poured into the electrode hole. The electrode rod shall then be lowered into the hole. The connections on the electrode rod shall be clearly accessible within the pit above the level of the earth enhancement compound and soil.

5.7.5 Earth Bars

The earthing installation drawings may detail the configuration for earth bars.

Earth bars shall be tinned copper and of minimum size 50mm x 6mm. The earth bar length shall be sized and pre-drilled to facilitate the termination of all earthing conductors as per the contract works plus additional 10% spare terminations. Earth bars shall be mounted using stainless steel brackets, stainless steel fixing hardware and fibre-glass reinforced nylon insulators. Disconnect links shall be provided on earth bars where required to facilitate testing and the ready isolation of buried earth grid connections or different earthing systems (i.e. instrumentation earth system).

Earth bars shall be uniquely identified with Urban Utilities Equipment tag names and updated in As-Built documentation where not specified. The labels shall be engraved stainless steel in areas exposed to the elements. Traffolyte (engraved multi-layered plastic) labels are accepted at indoor areas.

5.7.6 Earth Cables

Buried earth grid cables shall be bare (no insulation or sheath) single core 120mm^2 circular, stranded, annealed copper.

Earth bonds to moveable or hinged equipment shall be completed using braided, tinned, flexible copper cable. All other earth cables shall be green/yellow 0.6/1kV V-90 PVC insulated, circular, stranded annealed copper conductor. Green/yellow PVC tape shall not be used in lieu of conductor insulation.

5.7.7 Earth Connections

Above ground exposed cable taps, splices and connections shall be made via compression crimps. Crimps shall be sized to suit the cables and shall utilise the correct tool, dies and procedure as instructed by the crimp supplier. Crimp connections shall be primed and wrapped (Denso products or equivalent) to maintain the integrity of the connection. Crimped connections shall be inspected to confirm the integrity of the connection prior to wrapping.

Connections between earth bars and cables shall be completed using heavy duty copper crimp type cable lugs bolted to earth bars using stainless steel fixing hardware. Earth bar connections shall be coated with a primer (Denso product or equivalent) to protect against corrosion.

All above ground joints and connections shall be visible and accessible.

Earth cables shall be uniquely identified as per section 5.4.14 Cable Identification. Earth cable tag numbers shall be assigned where not specifically identified. Documentation shall be updated to As-Built with tag numbers assigned.

Buried earth connections, cable taps, splices and connections shall be made by either exothermic welding (Cadweld) or "C" compression connectors.

5.7.7.1 Buried Earth Connections Using Exothermic Welding

Exothermically welded connections shall be performed using products that have been qualified for substation grounding in accordance with the requirements of IEEE Std 837. Additionally, a safe and effective method for executing these connections shall be selected (e.g. ERICO Cadweld Plus System).

Cad-welding and pre-welding treatment of the conductors shall be in accordance with the instructions of the supplier of the cad welding equipment. Buried connections shall be inspected to confirm the integrity of the connection prior to burial.

5.7.7.2 Buried Earth Connections Using Compression Connectors

Details of the compression connection system proposed for each combination of conductor types and sizes to be joined shall be submitted to Urban Utilities for acceptance. Details shall include:

- Connector type (brand and part number)
- Compression die type (brand and part number)
- Compression tool type (brand and part number)

Connectors shall be suitable for direct burial in the ground.

The design of the connector shall allow the laying of two cables side by side when making a conductor/conductor connection.

"C" shaped compression fittings are the preferred compression type connector.

Compression connections shall be irreversible.

The combination of compression connector, compression tool and die shall be compatible and suitable for the conductor sizes being joined.

Compression tools shall be of a positive locking action that shall not release until the compression joint is completed.

Compression dies shall emboss the connector with markings to confirm that the correct die has been used for that connector.

Pre-treatment of conductors, compression fittings and dies shall be in accordance with the instructions of the compression fitting and tool suppliers.

Some form of anti-oxidant grease covering the inside of the connector is required for compression type fittings.

Compression connections shall be primed and wrapped (Denso products or equivalent) to maintain the integrity of the connection. Compression connections shall be inspected to confirm the integrity of the connection prior to wrapping.

5.7.8 Cable Earthing

Integral earth conductors, screens, metallic sheaths and protective metallic armours of HV and LV power and control cables shall be connected to earth at both the origin and destination ends unless detailed otherwise in equipment manufacturers' recommendations.

Typically, integral earthing conductors and screens shall be directly connected to the earthing facilities at both ends. Typically, the metallic sheathing and armouring shall be earthed via the cable gland onto the metallic gland plate which shall be bonded to the earthing facility at each end.

5.7.9 Cable Ladder

Cable ladders shall be electrically continuous and shall be bonded on one side of the ladder across the splice plates using 25mm^2 G/Y PVC cable bonds.

Additionally, the following cable ladders shall be bonded at the start, finish and at maximum 30 metre intervals to an equipotential bonding conductor (25mm^2 - 120mm^2 G/Y PVC) installed within the cable ladder system:

- Cable ladders within the electrical substation area
- HV Power cable ladders (35mm^2 minimum for these ladders)
- LV Power cable ladders (>20A per circuit)

The following minor cable ladder runs shall be bonded to the plant earth at the start and finish of the ladder runs only and shall be electrically continuous from end to end:

- Lighting and small power (≤20A per circuit) cable ladders outside the substation area
- ELV, control and instrumentation cable ladders outside the substation area

The earthing standard installation drawings shall detail the arrangement of the cable ladder earthing.

5.7.10 Lightning Protection

Lightning protection shall be incorporated as an integral part of the overall earthing system, and shall be installed in accordance with AS/NZS 3000, AS/NZS 1768 and where applicable, manufacturers' recommended procedures.

The general principals of equipotential earthing as described in Section 5.7 Protective Earthing and Lightning Protection shall apply, and in addition, particular measures shall be taken to ensure lightning protection system down conductors and earth pits are located in the closest practical proximity to the associated protected structures.

Down conductors shall be run true to building and equipment structures and shall be adequately supported to ensure no mechanical damage shall occur under the influence

of a lightning event, or wear typically associated with operation in heavy industrial environments. Any such down conductor supports shall not be solely fastened to sheet metal or cladding. Down conductors shall not be routed in trafficable areas and shall be clear of areas where persons may frequently occupy in normal operations.

Surge protection devices shall be installed according to the manufacturers' recommendations and shall in any case take due regard to minimise conductor lengths and excessive conductor bends. Surge protection devices shall be disconnected from circuit during insulation testing; any protection devices damaged during testing shall be replaced.

Refer to Section 5.7 Protective Earthing and Lightning Protection for lightning protection of areas with a Hazardous Area.

5.8 Lighting and Small Power

5.8.1 General

Lighting and Small Power shall be installed as per Project Documentation. Refer to Sections 3.7 Lighting and 4.16 General Power for design requirements.

5.8.2 Plant Lighting

Rows of lighting fixtures shall be accurately aligned and securely fixed such that the alignment will not be disturbed by normal plant operation, maintenance or weather conditions. Standard installation drawings shall detail the typical installation arrangements for the plant lighting. Light fittings shall be installed such that they are easily accessible and can be removed and replaced without dismantling conduit, brackets or similar.

The mounting arrangement of fittings and associated control gear and junction boxes shall be such that routine maintenance works can be completed safely. Particular consideration shall be given to light fittings that are to be located on or adjacent to handrails where maintenance work at heights may introduce the risk of falls from significant heights. In such instances hinged poles or similar shall be used so routine maintenance can be completed from the walkway level to eliminate such risks. Hinged poles shall be arranged to ensure the pole can be dropped and erected without clashing with other services or structure.

Hinged poles may be clamped to the walkway handrails using proprietary clamps. An RPEQ structural engineer shall approve the handrails suitable for fixing the light poles.

Light switches where required shall be installed at a height of 1.2m above the floor level or as otherwise specified.

Light fittings shall be mounted with a minimum 2.2m clearance below the fitting (unless detailed otherwise). If this clearance cannot be achieved the mounting of the fitting shall be accepted by Urban Utilities prior to erection. All luminaires and control gear shall be installed in accordance with the supplier's recommendations.

Generally, all light fittings shall be equipped with a dedicated junction box located adjacent to the light fitting in an accessible location. All light fittings and/or lighting

junction boxes shall be clearly labelled defining the supply circuit and light fitting tag number (where applicable) in accordance with Project Documentation. Lighting circuit identification may be achieved by cable labels if accepted by Urban Utilities.

Emergency lighting shall be circuited and installed in accordance with the relevant standards and statutory regulations. Dedicated circuits shall be used for emergency lighting and the associated distribution boards shall be equipped with facility for the necessary routine testing of the emergency lighting system. Where emergency light circuits are fed from a UPS, the UPS shall be standalone dedicated to only the emergency lighting in accordance with AS 2239.1.

5.8.3 Street and Area Flood Lighting

Free-standing street and area flood lighting shall be installed to enable easy and safe access to the luminaire and the associated control gear for maintenance works (i.e. hinged streetlight poles or similar). Hinged poles shall be arranged to ensure the pole can be safely dropped and erected without clashing with other services or structure. Similarly, area lighting mounted on plant or structure (i.e. floodlights on buildings) shall be installed to enable easy and safe access to the luminaire and the associated control gear for maintenance works. Standard installation drawings shall detail the typical installation arrangements for the street and area flood lighting. The mounting arrangement shall enable the light fitting to be adjusted to fine-tune the area illuminated. Light fittings and control gear shall be installed such that they can be removed and replaced relatively simply (i.e. without dismantling conduit, brackets or similar)

Free standing steel light poles shall generally be earthed through the steel reinforcement cage in their foundations, provided there is electrical continuity between the pole and the reinforcing steel. Light poles not earthed through their foundations shall be solidly earthed by a dedicated earth cable bonding the pole to either a dedicated earth electrode or the local main earth grid. Poles shall also be bonded to the earth in the lighting supply cable via an appropriately rated terminal strip.

In addition, street lighting poles connected via an earth bond shall be located in proximity to an associated earth pit to minimise the lightning path to earth. Street lighting and other free-standing light poles above 8m shall also be fitted with lightning surge diverters as specified in the standard installation drawings. Light poles shall be equipped with a lightning finial or similar for lightning protection.

For free standing light poles the footings and rag bolts shall be sized and installed in accordance with the structural foundation design. Grout shall be installed between the footing and pole structure. All poles shall be installed square and level and aligned when located in rows.

Light poles shall be clearly labelled defining the supply circuit and light fitting tag number (where applicable) in accordance with Project Documentation. Circuit identification may be achieved by cable labels if accepted by Urban Utilities. Each light pole shall be equipped with a gear tray or similar to facilitate cable termination and mounting of a fault protection device (fuse or similar). The cable termination and local

protection device shall be located in an accessible location for ease of maintenance works.

Luminaires and control gear shall be installed in accordance with the Supplier's recommendations.

5.8.4 Luminaires

Luminaires shall be LED.

Lamps and tubes of the specified type, size and manufacture shall be installed in the lighting fittings.

Luminaires shall be thoroughly cleaned after erection, shall be handed over in a clean condition and accurately focused.

All installations shall be completed to maintain the IP rating of the selected fitting.

Luminaires to be installed within hazardous areas shall be suitably certified and installed in accordance with the requirements of Section 5.13 Hazardous Area Installation.

5.8.5 Power Outlets and Switches

Refer to Section 4.16.1 Socket Outlets for selection and upstream protection requirements.

Unless otherwise specified, the following mounting heights shall apply:

Application	Height Above Floor Level
Switchroom & floor level socket outlets	200mm
Other socket outlets	1000mm
Service outlets to water boilers etc.	1300mm
Air conditioner & fixed high-level equipment outlets	1800mm

The power rating for light switches shall be matched to the circuit breaker rating for the supply circuit.

Where multiple outlets are supplied from a single circuit and the outlet cannot facilitate a loop-in loop- out of the nominated cable (i.e. cable size is too large to loop-in and loop-out) a break gauge junction box shall be installed adjacent to the power outlet.

5.8.6 Decontactors

Decontactors shall be installed on equipment as defined in Project Documentation. All Decontactors shall include an auxiliary contact to provide an input to the control system to define the status of connection of the equipment/Decontactor. Where Decontactors are to be used for local isolation they shall be equipped with a suitable facility for affixing isolation locks or hasps.

Decontactors shall have a utilisation of AC23. They shall have a polyester body where the circuit's motor has a full load current of 150A. Circuit ratings >150A shall use Decontactors with a metal body.

Flexible cable (PVC/PVC) shall be installed from the equipment to the Decontactor.

Decontactors shall be mounted 1.2m above the operating floor.

5.9 Instrument Installation

5.9.1 General Requirements

Instruments and associated components shall be installed in accordance with the standard installation documentation unless otherwise accepted by Urban Utilities. For any instruments that have not been defined in these documents, a proposed installation arrangement shall be submitted to Urban Utilities for approval. No Procurement, fabrication or installation shall not commence without the receipt of acceptance from Urban Utilities.

Instruments shall have individual connections to the process unless otherwise specified.

No Instruments shall not be installed so that it they depends for support upon:

- The impulse lines, unless so designed
- The electrical connection

The Supplier's installation recommendations shall be kept available on site and shall reviewed prior to the commencement of any installation works. All supplier installation recommendations shall be strictly followed. Any conflict between the standard installation documentation and the supplier's recommendations shall be brought to the attention of Urban Utilities for resolution. All brackets and fixings provided by the Supplier shall be utilised.

Equipment shall be levelled, squared with building lines and adjusted for operation. Anchors, gaskets, spacers, nuts, bolts, washers, shims, packers and all other similar materials shall be used as required.

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

5.9.1.1 Location

Instruments shall be located to facilitate ease of operation, inspection and maintenance. The instrument locations shall be in the approximate positions shown on instrument layout drawings. The final position shall be determined on site based on the approximate position. Consultation over the final positioning of instruments or if a conflict arises shall be agreed with Urban Utilities. Where the existing tapping point is

not suitable for the instrument the existing tapping point shall be modified or a new tapping point shall be installed.

Unless otherwise specified, remote mounted instruments shall be accessible for maintenance or removal. Operators shall be able to observe the display gauges whilst adjusting the related instruments. Where no permanent access has been provided, temporary or mobile access platforms shall be provided as required. Instrumentation shall be serviceable and replaceable without the aid of a ladder or scaffolding, unless accepted by Urban Utilities.

Instrument tube runs and cable trays shall not obstruct escape routes, walkways or access to plant or equipment which may require regular attention.

If the adjustment of one locally mounted instrument device affects the operation of another (such as local controllers and control valves), the devices should, where practical, be mounted so that both devices can be seen at the same time.

Instruments shall not be located outside the site perimeter boundary.

Indicating instruments shall be mounted so that their indications are clearly visible with no parallax error. Dial thermometers and pressure gauges shall be plainly visible and accessible from the ground or a platform.

Instruments shall be mounted with a clearance of at least 600mm per 40°C, for equipment with surface temperatures in excess of 90°C.

A minimum of 100mm clearance shall be provided around an instrument installation and any surrounding structure or equipment.

Wherever possible, instruments shall be located so that they are protected from damage by passing or falling objects. A clearance of at least 75mm from any handrail shall be provided.

Wherever possible, instruments shall not be exposed to dripping process materials. Where this is unavoidable, a suitable cover shall be placed over them. Instruments shall not be installed on walkways and safety routes so as not to obstruct personnel movement. Refer to Section 5.1.6 Mounting for Ergonomics for further requirements.

5.9.1.2 Mounting

Equipment and accessories shall be installed according to the drawings and information provided and in Project Documentation. Written approval shall be obtained before implementing any deviation from project drawings.

In-line instruments or equipment and level instrumentation mounted on bridles such as radar / magnetostrictive level transmitters and level gauges, will be installed by suitably qualified mechanical/piping fitters. This type of equipment shall be checked for correct installation once the mechanical/piping fitter has completed the

installation, and prior to installation of Electrical and Instrumentation components as per the Hook-Up drawings to make the installation mechanically complete.

Field instrumentation shall be mounted on instrument stands using appropriate brackets or shall be bracketed to suitable firm steelwork. Handrails or process pipework shall not be used for support unless otherwise directed in writing by Urban Utilities. Field-mounted instruments shall generally be mounted on instrument stands as per Section 5.1.7 Mounting Stands and Project Documentation.

Typical support brackets for pipe clamp-type mountings are shown in the Instrument Installation Hook-Up Drawings but can be modified as necessary to carry mounting plates for solenoid valves, pressure gauges, etc. as required.

The mounting of instruments and field devices to building cladding is not permitted.

Local indicators mounted directly in lines or on vessels shall be mounted to be visible and accessible for operation and maintenance, from grade or a nearby platform. Local indicators not mounted directly in lines or vessels shall be suitably mounted at a height of 1500mm above the floor or platform in a position accessible for operation and maintenance.

Instruments shall be mounted / connected so as not to stress vessel nozzles.

Instrument supports and brackets shall be located such that the instruments shall be as close as possible to the primary process connection and be consistent with instrument accessibility requirements for installation, operation and maintenance.

Instruments and instrument supports shall not be mounted on nor attached to equipment or structures subject to vibration.

Instruments or stands shall not be attached to any support structure nor shall they be supported off any handrail, grating or guard system without Urban Utilities' prior acceptance.

Where instrument support stands are not located on paved areas, a concrete plinth typically 300 mm square by 400 mm deep, shall be cast in the ground with no more than 100 mm projecting above the grade level and the stand bolted to this. Loxins or dynabolts may be used for securing stands to the concrete pavement.

Column mounted stands shall be clamped. Welding may be allowed under certain situations and but requires acceptance from Urban Utilities.

More than one instrument may be mounted on a common instrument stand where accepted by Urban Utilities.

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

Instruments fitted in areas where they are 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 transmitter.

Fittings such as instrument isolating valves and instrument air or gas regulators shall be supported either off the instrument stand or close-coupled to the instrument in manner such that no undue stress is imposed on the tubing installation.

Instruments shall be mounted as close as possible to the process connection. Lengths of impulse lines shall be minimised.

Instruments and instrument impulse lines shall be kept clear and supported independently of pipes, vessels, handrails, ladders, and personnel safety cages. Fixing to vessels shall only be permitted if the vessel manufacturer has provided cleats designed for fixing instruments and associated tray.

Fixing to fireproof members shall be accomplished prior to the application of fireproofing, using brackets with extended stand off to provide adequate clearance for application of fire proofing.

Mounting of instruments directly on to the process pipe connection is permissible only where specifically designed for direct mounting, capable of withstanding line induced vibration and the pipe connection is designed to withstand the associated stresses. Instruments installations designed for direct mounting will be shown on the applicable hook up drawings.

Welding or fixing operations shall not be carried out on any process plant equipment, vessels or pipelines, unless specifically indicated on the installation documents.

To avoid corrosion traps, an inhibitor such as Silicone or nickel-based grease shall be applied to bolt threads when bolting through drilled holes and threaded mounting points.

For polymer tanks and other vessels with non-rigid walls and roof the instrument installation associated with these types of vessel shall allow for contraction and expansion of the tanks under normal filling and emptying. PVC backing rings shall be installed where metal fittings are in union with PVC flanges.

5.9.1.3 Instrument Earthing

Refer to the requirements laid out in Section 3.4.17.8 Instrument Earthing.

5.9.1.4 Pressure and Differential Pressure Instruments

Pressure, DP and flow DP instruments shall be installed in accordance with the relevant hook up drawings.

Where pipe stand mounted, they shall be installed as close to the process tapping as possible.

Pressure gauges shall be installed with rotatable gauge adaptors in accordance with appropriate hook up drawings.

The capillary tubing of filled and sealed instruments shall be adequately supported and protected from damage. The capillary tubing shall not be cut or removed. Any extra length shall be neatly coiled at the instrument end of the tubing. The manufacturer's minimum recommended bending radius shall be followed for any bends required.

Open ports on field mounted instruments shall be protected by installing a length of tubing, fitted with a bug screen.

5.9.1.5 Level Instruments

Each instrument connected external to the vessel or standpipe shall be installed on full bore piping isolation valves. The exception to this may be radar level transmitters where the transmitter may be removed whilst leaving the probe installed.

If during installation it becomes apparent that future removal may be difficult, Urban Utilities shall be notified before any corrective action is taken.

Level instrument installations shall be installed to permit maintenance from a platform or deck. Isolation, vent and drain valves shall be accessible.

The vessel and bridal connections to level instruments shall be aligned to within +/- 20mm, to ensure the external chamber is mounted vertically without exerting any stress on the instrument or galling of the float or displacer within the chamber. Where it is evident that this is not achieved, Urban Utilities shall be notified.

Ultrasonic level instruments are not permitted in high humidity areas.

5.9.2 Temperature Instruments

Temperature instruments such as gauges, thermocouples and resistance temperature devices shall be installed in thermowells, unless specified as surface mounted or indicated otherwise on the datasheets and installation drawings.

Temperature sensors shall be coated with thermally conductive oil prior to sensor insertion. The use of molybdenum disulphide greases are not permitted.

Prior to installation, following shall be checked. A site query shall be raised if any of these conditions are not met:

- There is sufficient clearance for inspection and withdrawal of the thermowell and their associated temperature measuring instruments
- The thermowell would be fully immersed in liquid when fitted to a vessel

For surface mounted temperature transmitters, the temperature instrument shall be installed in accordance with manufacturer’s recommendations.

Test thermowells, if any, shall be fitted with 316 SS weather proofing plugs and securing chains.

5.9.3 Flowmeters

5.9.3.1 Variable Area Flowmeters

Variable area flow meters shall be mounted in accordance with the manufacturer's recommendation (usually vertical with flow upwards) and piping isometric. The meter must be orientated to allow easy reading of the scale.

Transducers shall not be removed from spool pieces.

5.9.3.2 Orifice Plate DP Flowmeters

Differential pressure transmitters for liquid service shall be located below orifice flanges.

DP Flow transmitters in gas and vapour service shall be located above the orifice flanges.

Orifice meters should be installed horizontally and near the deck or platform for ease of accessibility and safe changing of the orifice plate.

It is not permitted to install an orifice meter such that the person changing the orifice plate is required to stand directly over the top of the fitting.

Flange bolting shall be fully withdrawable and not obstruct the vertical orientation of the tab on the orifice plate. The orientation shall be checked prior to the welding in place of a meter run.

The instrument orientation and location shall allow for adequate space to access and clear blockages from all lines.

5.9.4 Control and Shutdown Pushbuttons

These shall be mounted on instrument stands or a bulkhead. Where multiple pushbuttons are required at the same location these can be grouped on a common stand if practical. Pushbuttons shall not be placed where susceptible to damage or inadvertent operation. Each pushbutton shall be clearly labelled with a large laminated plastic label. Shutdown pushbuttons shall be clearly visible from the escape routes and the walkways and not obstructed by site run equipment.

5.9.5 Control Valves, Shutdown Valves and Relief Valve

Valves shall have facility to be pad locked in open and closed position.

Actuated valves installed in horizontal pipes shall have their actuators above the valves.

Actuated valves installed in vertical pipes shall have the actuators orientated in line with the pipe and in an accessible position to read display and access terminal box. Extension spindles shall be installed to eliminate requirement for access to confined spaces and in other areas where access is restricted.

Diaphragm and piston actuated linear valves (e.g. control valves), shall always be installed with their stems vertical.

Relief valves shall be installed with the spindle in a vertically upward position.

Access shall be from the access platforms, as required.

Elbows shall be installed to all vent pipes to direct discharge to ground.

Clearance shall be provided to allow in-line maintenance of the valve. Adequate clearance shall be provided above, below and around the valve to allow removal of the valves internals and actuator, without the need to remove the valve body from the pipe. Where it is not feasible and the valve is flanged, it may be swung on a bolt axis to provide access.

5.9.6 Tubing, Piping and Fittings

Polyethylene tubing and compression fittings may be utilised for instruments for general purpose electromechanical actuator valves and other equipment.

Tubing and fittings shall be in imperial sizes and SS316 Swagelok® compression fittings for instrument air supply to API 607 fire rated control valve installations and compressed air tubing up to the air dryer. The tubing shall be seamless cold drawn, annealed and pickled, ASTM A269 TP316/316L with a minimum molybdenum content of 2.6% (hardness maximum of 80 HRB), unless another material is required for corrosion or other reasons. Alternatives tubing and fitting materials shall require Urban Utilities' acceptance.

Process connections and tubing shall be installed as per the P&ID's and Process and Pneumatic Hook-Up drawings. Any deviation from these must have prior acceptance by Urban Utilities.

Tubing expansion sets should be installed to prevent stresses resulting from expansion where extreme vibration or changes in temperature may occur.

Tubing shall be supplied and installed in accordance with Urban Utilities' specifications and shall be fully annealed, seamless, cleaned and passivated ASTM A269-10TP 316/316L SS unless otherwise stated in the Hook-Up drawings or agreed in writing with Urban Utilities.

Tubing installation shall be neat in appearance, round, free from external scratches and defects, grouped functionally together where practical. All tubing shall be run in either the horizontal or vertical plane except as specified for impulse tubing to achieve the prescribed fall.

Fittings shall meet or exceed the piping specification that they serve.

Tubing and fittings shall be as detailed in the Instrument Installation Hook-Up Drawings.

Full material certification shall to be supplied for all materials.

Tubing must be imperial sizes. Only NPT type thread can be used for threaded connections. Any deviation from this shall be subject to Urban Utilities acceptance.

Tubing shall be pickled free of scale. When bright annealing is used, pickling is not necessary.

Tubing shall not interfere with access to valves or equipment, nor obstruct passageways. A headroom clearance of 2500mm minimum shall be maintained beneath all piping, valves and fittings installed above access ways.

Instrument valves shall be accessible for operation from floors or platforms unless otherwise accepted by Urban Utilities.

Tubes installed, but not connected, shall have the ends closed in to prevent the entry of foreign material. For a period of up to one week adhesive tape may be used, for longer periods, caps or plugs shall be used.

Joints should be systematically staggered and neatly offset when instrument pipes or tubing is run parallel to each other.

Only double ferrule compression fittings like Swagelok® shall be used for all tube connections.

Nuts and ferrules shall be confirmed to be of the same grade, size and of the same manufacture. The fittings shall be installed in strict accordance with the Manufacturer's recommendations, including checking with a gap inspection gauge where relevant.

The mixing of different manufacturer’s compression fittings shall not be permitted.

Any discrepancies between the materials/fittings specified and the materials/fittings provided as free issue items shall be resolved with Urban Utilities.

Horizontal runs of tubes shall have tubes laid vertically one above the other as far as possible and shall be run with the minimum number of changes of direction consistent with good practice and neat appearance. Standoff mountings shall be used rather than saddles to secure the tubes.

Pneumatic signal tubing shall be cleaned before connection to instruments by blowing through with filtered air.

Single core tubing shall be neatly run using cable tray, Unistrut® trunking or structural steel sections in such a manner as to give the maximum protection against mechanical damage wherever necessary.

Special attention shall be paid to the correct positioning of vents and drains to ensure that they are at the highest or lowest points of the piping run as necessary for effective operation. Stainless Steel mesh shall be installed to all vents and drains to prevent vermin ingress.

Impulse tube shall be kept as short as possible consistent with good practice and accessibility. As far as possible, the process impulse lines shall be run in the vertical plane, all horizontal tubing shall be run with a minimum slope of 1 in 12. Tubing for liquid service shall slope downward toward the instrument to ensure self-venting of vapours back to the main process. Tubing for gas service shall slope upward toward the instrument to ensure self-draining of liquids back to the main process.

Where the instruments are installed on immiscible fluids services the impulse lines shall be installed horizontally. These instrument orientations are shown on the relevant hook up drawings.

Impulse tubes for remote located instruments shall be arranged to avoid:

- Movement (thermal expansion) exerting force on the connection and tubing
- Mechanical damage from impact
- Rubbing on valves or steelwork

Where indicated on the hook up drawings instrument manifold vents shall be tubed to the vent header to allow remote safe venting of gases.

Piping and tubing shall be supported by tube clamps to provide adequate mechanical security and installed so that no section or run is left under strain.

Impulse tubes shall be supported with tube clamps (e.g. STAUFF) at a spacing not exceeding the following:

Tube Size	Tube Clamp Spacing
½" OD	1.5m
3/8" OD	0.75m
¼" OD	0.5m

Alternatively, tubing may be continuously supported in trays.

Tubing shall not be run in electrical cable trays.

Where impulse lines are heat traced and / or lagged provisions shall be made to allow the removal or maintenance of the instrument without removing the entire heat tracing or lagging.

Breakable connections shall be provided adjacent to the instrument to facilitate instrument removal.

Tubing shall be run in a single layer wherever possible with the minimum number of changes of direction and where unions are used; joints shall be offset neatly and shall be systematically staggered when two or more lines run together.

The installation shall facilitate uncomplicated tracing, troubleshooting and replacement.

Tubing runs shall be arranged so couplings may be tightened without distorting or bending the line.

Impulse tubes shall be bent where necessary using tube benders. There shall be no reworking of tubing and no tight bends. Where a tight bend (<3D radius) is unavoidable an elbow compression fitting shall be used instead.

Impulse tubes shall be lagged, or heat traced and lagged, where the process liquid would otherwise condense, solidify or be otherwise adversely effected by low or high ambient temperatures or where indicated on the installation drawings. Lagging shall also be provided to protect personnel from high or low temperature impulse lines.

Tubes shall be adequately supported and may be run in the horizontal or vertical plane. Where tube runs are horizontal and there is a possibility of oil or dirt falling on tubes, a protective cover shall be installed.

Tubing fittings with galled or deformed threads shall not be installed.

Tube fittings shall be correctly sized to match tube connections instead of bushings or swages. The use of bushings is prohibited.

Proper tightening of tubing fittings shall comply with the tubing manufacturer's requirements.

Manufacturer’s Go / No- Go gauges shall be used to check the gap.

The temperature rating of sealer/lubricant compound shall not be exceeded.

Precautions shall be taken to prevent foreign material entering the instrument tubing before or during installation. Lines shall be blown with oil-free dry air before being connected to instruments.

Instrument tubing shall be free of burrs, square cut with a tubing cutter and reamed at end points as per Manufacturer’s recommended practice. Reamed tubing shall be blown completely free of shavings.

Fittings shall be tightened and checked using fitting gauges as per manufacturer recommended practice. Pressure ratings of female fittings shall be considered in evaluation of overall tubing system pressure capability.

5.9.7 Thread Tape and Sealing

On tubing connections:

- Threaded connections shall be assembled with SWAK (or equivalent) PTFE-free pipe thread sealant where compatible with the process substance.
- Thread sealant tape such as PTFE shall not be used.
- An appropriate thread sealant (Loctite) or lubricant shall be used in the place of thread sealant tapes where compatible with the process substance.

Sealants for special applications and the method of installation shall be accepted by Urban Utilities before commencement of installation.

5.9.8 Instrument Air Supply System

Instrument air manifolds shall be mounted vertically and fitted with a drain valve. The instrument tube shall be labelled with the instrument tag number at the point of isolation, normally the air distribution manifold. Tag number labels shall be attached to the tube using 316 SS banding.

Instrument air systems shall be clearly identified and labelled to prevent non-instrument usage.

Spare air manifold take-off points shall be plugged with 316SS threaded pipe plugs. The final tubing run shall be fabricated to reduce the effect of vibration and facilitate easy removal of the control valve or actuated valve.

Instrument air consumers requiring direct connection to the instrument air header (e.g. large pneumatic on/off valve actuators) shall have a 1” NB pipe run to the equipment. The final tie-in shall be in accordance with detailed installation drawings.

5.10 Fire & Gas Systems

Fire and Gas detectors shall be located, including elevation and orientation in accordance with the Instrument Location Plans and the BCA.

5.10.1 Fire Indicator Panel

Fire Indicator Panels (FIP) shall be installed inside the switchroom building in a metal wall mounted enclosure complete with digital display and LED indicators and control pushbuttons.

The enclosure shall be key lockable.

5.10.2 IR Point Gas Detectors

Gas detectors shall be mounted from secondary or tertiary steelwork. Detectors that cannot be accessed from the ground shall be installed complete with ¼" stainless steel tube down to a calibration point placed 1.3m above the ground but shall not obstruct escape routes. The tubing shall be fitted with a quick connect fitting that blocks the end of the tubing when not connected to a calibration gas bottle. A short length of plastic tube shall be fitted between the detector and the 316SS tube to avoid putting undue pressure on the detector cowling.

5.10.3 Open Path Gas Detector

Open path gas detectors shall be installed as per the manufacturer's guidelines with respect to the path lengths and clear line of sight. These devices are susceptible to loss of alignment if vibration at the instrument is present, therefore the design of the mounting poles and mounting of the instruments shall prevent vibration, meet the manufacturer's requirements and utilise recommended alignment tools. The path length shall be confirmed to be least 20% shorter than the maximum recommended by the manufacturer before final mounting of the device. The limitation on distance shall not be compromised unless accepted in writing by Urban Utilities.

Testing utilises a plastic film placed in the IR beam or with a tube filled with calibration/test gas.

Where feasible the height of the detectors shall allow the film to be placed into the beam but shall not allow normal platform activities to obstruct the detector path (e.g. personnel walking around the platform).

5.10.4 Acoustic Gas Leak Detectors

Acoustic gas leak detectors shall be installed as per the manufacturer's guidelines. Acoustic gas leak detectors shall be fitted with a sunshade when installed outside.

Acoustic gas leak detectors are susceptible to vibration and shall be installed in a vibration free location.

5.10.5 Fire Alarm Manual Call Points

Break glass units and pushbuttons shall be installed 1.4m from the floor level or deck level. Manual Alarm Call points and pushbuttons, complete with labels shall be mounted on an instrument stand and in accordance with the BCA.

Where manual call points are specified they shall be located at each exit door to HV and LV Switchrooms and wired to the switchroom FIP. MCPs located internal to switchroom shall be to AS 7240, and surface mounted. All cable penetration to MCPs shall be bottom entry.

Refer TMS1188 *Demountable Switchroom* for fire detection systems in demountable switchrooms.

5.10.6 PAGA Speakers

PAGA speakers shall be provided in the switchroom.

5.11 Switchroom HVAC Systems

Ventilation ducts between rooms (if any) shall be fitted with fire dampers controlled by the FIP.

Flood level shall be assessed when determining the final location of the condenser units.

5.12 Closed Circuit Television

Refer TMS176 *Security Design Guidelines* for design and installation requirements.

CCTV systems shall not utilise the same network hardware, enclosures or cabling used for process control or other services. Dedicated network switches and fibre cables shall be installed for all new and modifications to CCTV systems.

5.13 Hazardous Area Installation

5.13.1 Hot Work

A Hot Work permit is required if welding, cutting or using other spark producing tools such as test instruments in a hazardous area. Alternative work methods such as using certified non-hazardous test instruments and removing all possible ignition sources from the HA shall be utilised wherever possible.

For all Hot Works, a gas test shall be performed before work commencement and at regular intervals specified on the Permit to Work.

Refer to AS/NZS 60079.14 for other restrictions on equipment permitted in Hazardous Areas.

5.13.2 Wiring and Conduit Systems

Wiring system permitted in HAs shall comply with the requirements of AS/NS 60079.14.

Cables run external of HA equipment enclosures shall have flame propagation properties to IEC 60332.1. PVC sheathed cables manufactured in Australia generally comply with these requirements, however this shall be confirmed prior to installing the cables.

Cable selection also depends on the HA zone, the nature of the environmental hazards, the T-class of enclosures and the voltage carried by the conductors.

Installation of conduits systems must prevent the transmission of flammables and combustibles through the conduit to other hazardous areas or non-hazardous areas. This requires the use of sealing devices (example a “Y” Seal).

Additional requirement of conduit systems to be referred to AS60079.14 Clause 9.4

5.13.3 Enclosures & Cable Entries

Enclosure covers or doors shall be correctly held closed with the full complement of certified screws or other fasteners. Unused cable entries shall be plugged, ensuring that the plugs have correct mating threads to maintain IP rating and explosion protection. Shipping bungs are not acceptable for plugging unused entries unless they have appropriate explosion protection.

Certain Ex equipment such as Ex e or Ex n enclosures may have additional cable entries drilled or modified (within bounds of certification or manufacturer’s approval). Cable entries into Ex d enclosures are not permitted to be drilled or modified on site. Item selection shall ensure sufficient cable and conduit entries of the correct size for the Works. Unused entries are to be sealed using a plug device suitable for the particular explosion technique

5.13.4 Intrinsically Safe Equipment

Marshalling and junction boxes used for intrinsically safe (I.S. or Ex i) circuits need not be HA certified but shall meet the requirements for enclosures of intrinsically safe equipment defined in AS/NZS 60079.25.

A multi-core cable containing intrinsically safe circuits shall not contain any non-intrinsically safe circuits. Intrinsically safe cables shall be segregated from non-intrinsically safe cables as per Section 5.4.8 Cable Segregation.

Where intrinsic safety associated equipment (barriers/isolators) are installed on packaged equipment, I.S. transformer isolators shall be preferred to shunt diode safety barriers. I.S. isolators installed in hazardous areas shall be protected by a suitably certified explosion protected enclosure.

Barriers and isolators shall be installed strictly as directed by the Manufacturer, using the correct proprietary components. Each barrier and isolator position shall be labelled to show the correct barrier/isolator type to be used in that position.

Barriers shall be mounted in strips.

Ducts shall be so arranged that the intrinsically safe wiring and the safe area wiring are completely segregated in different ducts.

Linked terminals shall be provided for control supply active and neutral rails.

Each isolator's power supply terminals shall be wired directly to the control supply rails - there shall be no looping of wires between isolator terminals.

Intrinsically safe wiring, ducting and terminals within equipment panels, marshalling boxes and barrier enclosures carrying intrinsically safe circuits shall be marked as such. Slotted PVC ducts carrying intrinsically safe wiring shall be labelled 'INTRINSICALLY SAFE WIRING' or coloured light blue.

Cable entries into an I.S. enclosure shall satisfy the IP rating of the enclosure and meet the requirements of intrinsically safe equipment defined in AS/NZS 60079.25.

5.13.5 Flameproof Equipment

Flameproof (Ex d) rated equipment shall be installed in accordance with the relevant Australian Standards. Ex d rated equipment shall not be drilled or modified by anyone other than the equipment Manufacturer in accordance with the certification documents.

Flameproof enclosures shall not be drilled or drilled and tapped.

Sealing tape or other material shall not be applied over flame paths

All Ex d rated enclosures shall be closed using all screws, bolts or fasteners provided by the Manufacturer for such purposes. All such screws, bolts or fasteners shall be correctly tightened.

Empty screw and bolt holes will not be accepted. Missing screws, bolts and fasteners shall be replaced with a certified spare provided by the enclosure Manufacturer.

Thread tape and sealants shall NOT be used on any entry to a flameproof enclosure. Mating faces of equipment flanges and screw threads shall be coated with a non-setting non-combustible, corrosion inhibiting compound specifically approved for this use by the enclosure Manufacturer.

Flame paths shall not be greased except using an approved compound. Flame must be long enough to cool exhaust gases as they pass through. Their (MESG) maximum Experimental Safe Gap shall be taken into consideration at design and installation.

Ordinary greases shall not be used.

Use of gaskets is only permissible when supplied with flameproof enclosures and shall be strictly installed as per the Manufacturer’s instructions. Gaskets damaged during installation shall be replaced.

Unused cable entries shall be plugged with certified Ex d rated conduit plugs, ensuring that the plugs have correct mating threads to maintain IP rating and explosion protection. All bungs and adaptors shall be certified to the same standard as the enclosure.

Conduits entering a flameproof enclosure shall be sealed immediately adjacent to the enclosure.

Sealing shall be by means of a Y-seal or equivalent device.

Ex d motors supplied at varying frequency and voltage by a converter requires that the motor has been type tested with the specific converter and with the protective device provided or a means for direct temperature control by embedded temperature sensors specified in the motor documentation shall be provided, as per AS/NZS 60079.14 clause 10.6.1.

Care shall be taken to ensure that the minimum distance is maintained between the flame path of the flameproof equipment and any solid objects as per AS/NZS 60079.14 clause 10.2.

When mounting equipment, the mounting holes provided by the Manufacturer shall be used.

Additional mounting holes shall not be added to flameproof equipment.

Care shall be taken to ensure that threads of Flameproof cable gland, adaptors or blanking elements correctly mate with the equipment, that there shall be at least 5 full thread engagements.

Where thread form of the equipment entry is different to the thread of the cable gland or blanking element, only one adaptor shall be used per entry.

Gland connection shall be correctly sealed to maintain the IP rating of the equipment.

Cable entries into an Ex d enclosure shall utilise a flameproof cable gland incorporating compound filled seals which seal around individual cores or other equivalent sealing arrangement.

Application of “loctite” or similar thread sealants shall not be acceptable on flameproof enclosures.

5.13.6 Increased Safety Equipment

Increased safety (Ex e) enclosures with only an Ex enclosure component certificate (marked with a ‘U’) shall not be installed.

Ex e enclosures shall have a degree of ingress protection of at least IP54.

Cable lengths inside the enclosure should not exceed the diagonal length of the enclosure and additional terminals shall not be added to enclosures as these are the factors on which the maximum heat dissipated calculations are based upon.

Maximum power dissipation calculations shall be done if additional terminals are added and/or cable lengths exceed diagonal length of the enclosure, to ensure

calculated dissipated power is less than the rated maximum dissipated power of the enclosure.

Only certified cable glands, with a minimum IP rating of IP 54, or as required by the location, shall be used. Sealing washers shall be installed to seal the gland entry and maintain the IP rating of the enclosure.

Only certified Ex e terminals shall be used for conductor terminations. Terminal screws (including empty terminals) shall be tightened to the correct torque.

Damaged terminals shall be replaced.

Ex e motors supplied at varying frequency and voltage by a converter shall have been type tested for this duty as a unit in association with converter and protective device.

Ex e protection is critically dependant on coordination of the circuit overload protective device with the temperature rise characteristics of the Ex'e apparatus.

For Ex e motors tripping time shall be confirmed to be no longer than that on the motor nameplate. Tripping times shall be verified in the hazardous area check sheets.

Unused cable entries into Ex e enclosures shall be plugged using Ex e certified bungs.

Only certified cable glands, with a minimum IP rating of IP54, or as required by the location, shall be used. Sealing washers shall be installed to seal the gland entry and maintain the IP rating of the enclosure.

Only certified Ex e terminals shall be used for conductor terminations. Terminal screws (including empty terminals) shall be tightened to the correct torque.

Damaged terminals shall be replaced.

5.13.7 Non-Sparking Equipment

Non-sparking (Ex n) equipment shall only be installed in Zone 2 hazardous areas. Restricted breathing enclosures shall not be used in gas group IIC areas. All non-sparking enclosures shall have a minimum IP rating of IP54. All gaskets provided with equipment shall be correctly fitted and undamaged at completion of the contract.

Non-sparking (Ex n) motors supplied at varying frequency and voltage by a converter requires that the motor has been type tested with the specific converter or a means for direct temperature control by embedded temperature sensors specified in the motor documentation shall be provided, as per AS/NZS 60079.14 clause 14.4.2.

Only certified cable glands with a minimum rating of IP54, or as required by the location, shall be used.

External housings and accessories attached to non-sparking equipment (e.g. motor fan cowlings) shall be of non-sparking materials.

5.14 Signs and Labels

Every item of electrical equipment shall be provided with a clearly visible tag label showing the unique tag identifier for the item.

Warning and indicating signs and labels shall be provided in accordance with Project Documentation and the relevant codes, standards and regulations.

Refer to the requirements related to control panels in TMS1733 *Control Systems General Specification* for labelling requirements within control panels. Terminals for connection of external cables into enclosures shall be clearly identified.

A label shall identify each major sub-component of a piece of electrical equipment (e.g. UPS system battery banks, chargers and inverters). The label material, size, wording and layout of the label, must be in accordance with the standard drawings, equipment list and instrument index.

Minor sub-components (e.g. motor heaters, RTDs etc.) shall be fitted with labels identifying their individual tag number only.

5.14.1 Signs

Warning signs shall be positioned to ensure they are clearly visible and not obscured by any other item of equipment. Signs at building entrances shall be positioned to ensure the sign is clearly visible from the approach side with the entrance door open or closed.

Danger and warning signs shall be in accordance with AS 1319 and shall have zinc-anneal surface protection or equivalent.

The following signs shall be installed as a minimum:

- Signs denoting 'Danger' and applicable voltage (e.g. High Voltage, 400V, etc) at each switchroom door and each transformer or switchyard enclosure and gate
- Signs denoting 'Danger High Voltage' at appropriate intervals not exceeding 50m, and at each change of direction along HV cable ways on cable ladder, etc. These signs shall be positioned such that they are readily visible from walkways, roadways over which HV cables pass
- Signposts along underground cable routes to identify the cable route and location of in-line cable joints. Labels shall be installed on pit covers, where joints are made in pits
- Signs on cable ladder to identify the location of in-line cable joints
- Signs for substation/switchroom entrances denoting access by authorised persons only
- Signs denoting 'Warning Confined Space' for electrical cable pits, ducts and the like that shall be classified as confined space areas under the applicable codes and regulations
- Signs on HV switchrooms and other HV equipment shall comply with AS2067
- Signs indicating emergency routes to the nearest hospital and emergency phone numbers shall be displayed in a visible location as per AS2067

- Signs on switchboard compartments indicating maximum voltage level in the compartment
- Signs on switchboards indicating where all voltage sources are fed from
- HV and LV switchrooms shall be fitted with an electric shock survival sign (in accordance with Australian Resuscitation Council guidelines) mounted in a prominent location
- Any signs not specified in Project Documentation required for compliance with relevant regulations, codes and standards

5.14.2 Equipment Labels

Electrical equipment shall be labelled by means of permanently attached tag labels in accordance with Project Documentation and the equipment schedules.

The Standard Label Drawings shall identify the requirements for labelling electrical equipment. These drawings shall detail the label material, label size, text size, label configuration and fixing arrangement for each type of label.

A typical label for each type of equipment shall be submitted to Urban Utilities for approval prior to ordering or manufacturing any labels.

Where it is not practical to mount labels on the equipment they shall be mounted on the adjacent steelwork or equipment mounting bracket stand. Equipment mounting stands and brackets shall be provided with provision for mounting labels. In all instances equipment labels shall be clearly visible from the walkway or equipment operating position.

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

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

Refer to TMS 1647 *Plant and Equipment Tag Numbering* for details on how equipment shall be tagged.

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

Application	Label Colour	Text Colour	Notes
Instruments	White	Black	Labels are in addition to the stainless steel tag plates supplied with the instrument
LV & ELV enclosures	White	Black	Including switchboards, control panels and junction boxes
Electrical Field Equipment	White	Black	Including motors, transformers etc.
Junction boxes containing shutdown or safety circuits	Red	White	

Label letter height shall be generally as follows:

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

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

Equipment tag name labels shall not be attached to cladding.

Labels that will be exposed to paint spray shall be temporarily masked with a transparent material during construction, then removed at Handover.

5.14.2.1 Hazardous Area Labels

The Manufacturer's HA certification nameplate shall be affixed to each piece of explosion protected electrical/instrumentation equipment. Equipment shall be located and orientated such that nameplates are visible for inspection. If the serial number does not match the Manufacturer's information then the HA dossier shall be consulted to determine if the modification is authorised or not. Urban Utilities shall be immediately informed of each mismatch.

Where the Manufacturer's HA certification nameplate is illegible or inaccessible from a safe inspection location, or if the label is of a type that may become illegible in the future, the relevant information may be duplicated on an etched stainless-steel tag attached to the equipment via stainless steel wire. The label shall include the following information at minimum:

- Tag Number
- Manufacturer
- Model Number
- Serial Number
- Manufacture Date
- Full "Ex" marking as per the Certificate of Conformity, including:
    - Protection Method
    - Gas/Dust Group
    - Temperature Class
    - Equipment Protection Level (if applicable)
- Certificate of Conformity number & issue
- Certificate Date of Issue

5.14.3 Danger and Warning Labels

Electrical enclosures shall have each applicable warning label affixed to the front of or adjacent to the enclosure. Laminated traffolyte danger and warning labels shall have slotted holes and shall be attached to the equipment where appropriate via stainless stainless-steel screws or bolts. Danger and warning labels shall comply with AS 1319.

Application	Label Colour	Text Colour	Text
All LV enclosures	Red	White	DANGER zzz V FED FROM PANEL xxx CB yyy
Removable covers, terminal boxes etc. housing normally live terminals or busbars	Red	White	DANGER LIVE TERMINALS ISOLATE ELSEWHERE BEFORE REMOVING COVER
Equipment connected to the line side of an incoming switch (e.g. voltmeters)	Red	White	DANGER LINE SIDE CONNECTION ISOLATE ELSEWHERE
Terminal box for motor heater fed from auxiliary 230V AC supply	Red	White	DANGER THIS CIRCUIT ENERGISED WHEN MOTOR IS ISOLATED ISOLATE BEFORE OPENING
Motor RTD terminal box	White	Black	RTD TERMINALS DO NOT MEGGER
Motors with insulated bearings	White	Black	CAUTION: BEARINGS MUST BE KEPT INSULATED
HV Switchroom Battery Charger Distribution Boards	White	Black	BATTERY CHARGER SUPPLIES FOR HV SWITCHROOM EQUIPMENT ONLY - DO NOT CONNECT TO EXTERNAL EQUIPMENT
Enclosures with ELV as the highest voltage	White	Black	zzz V FED FROM PANEL xxx CB yyy
Large field junction boxes for Intrinsically Safe circuits	Blue	White	IMPORTANT INTRINSICALLY SAFE CIRCUITS ONLY
Other enclosures containing Intrinsically Safe circuits	Blue	White	INSTRINSICALLY SAFE WIRING INSIDE
Emergency Stop Pushbuttons	White with Yellow Ring	Black	EMERGENCY STOP
FOBOTs and other FO-containing enclosures	Yellow	Black	WARNING FIBER OPTIC CABLE

Where ‘xxx’ and ‘yyy’ are equipment tag numbers and ‘zzz’ is the highest voltage level within the enclosure. The intent is that personnel need not refer to electrical documentation to be able to quickly locate and isolate all voltage supplies to an enclosure.

CBs feeding fire services equipment; emergency lighting and other circuits related to personnel safety shall have warning labels that comply with relevant industry standards, particularly AS 2293.1.

5.15 Quality Assurance, Inspection and Testing

All works shall be demonstrated to comply fully with the Specification and associated Project Documentation.

5.15.1 Quality Assurance

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

A quality control program shall be submitted for Urban Utilities' review prior to an agreement regarding Works being reached (i.e. at Tender or as appropriate for the Works). Cooperation with Urban Utilities and Urban Utilities' nominated auditors shall be furnished 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 accepted by Urban Utilities. Hold (where applicable) and witness points for access by Urban Utilities shall be nominated in the Inspection and Test Plans.

5.15.2 Inspection and Testing

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

Test equipment, tools and materials required shall be supplied and these shall be fit for purpose, in good working condition and calibrated. Test equipment shall be certified and traceable to an applicable standard. Before testing or calibration commences a comprehensive list of test equipment intended to be used, along with copies of calibration test certificates, shall be submitted to Urban Utilities for review. Calibration certificates shall be maintained for all relevant equipment.

Test equipment for instrumentation shall have a standard of at least three (3) times better accuracy than the Manufacturer's stated accuracy for the target instrument (i.e. an error range <33% of the target instrument's) and shall be calibrated within six months of the test date.

5.15.2.1 Inspection and Test Plan (ITP)

Each work package shall include an Inspection and Test Plans (ITP) to ensure each key step or procedure of the installation process has the necessary review, hold and or witness points to ensure the required level of quality assurance is delivered.

ITPs shall list typical inspections and tests proposed for all elements of the works. ITPs shall encompass testing requirements from all relevant standards, statutory/regulatory requirements as well as best practice in engineering and construction/installation.

Typical Inspection and Test Plans (ITP) shall be included in works proposal documents (e.g. Tender documents). Prior to Works commencement, typical ITPs shall be customised for the Works for Urban Utilities' review and acceptance. Final versions of ITPs shall be signed off by all parties involved in the Works, including Urban Utilities. Signed-off ITPs shall thereafter form part of Project Documentation.

Urban Utilities shall have the right to witness any or all inspections and tests.

ITPs and associated check-sheets shall be completed and signed off progressively by the Accountable Party during the Works execution to demonstrate defined testing requirements, regardless of whether tests are witnessed by Urban Utilities.

The Contractor shall give Urban Utilities at least five (5) working days' notice of its intention to perform an inspection or test so that Urban Utilities may arrange for the relevant representatives to attend and witness the inspection or test.

Where inspections or tests are to be undertaken outside the South-East Queensland, an extended notice period shall be provided as follows:

Within Australia (or New Zealand): seven (7) working days
Outside Australia: four (4) calendar weeks

Where appropriate, test check-sheets shall state values for all test results. Tests with pass/fail results shall be qualified by the relevant acceptance criteria.

The following typical documents outline the minimum content to be completed where applicable to the site testing and inspection works:

- FOR279 Site Details & Test Sheet – Electric Motors
- CHE69 Site Inspection Checks – Electric Motors
- CHE68 Site Inspection Checks – Cables
- CHE70 Site Inspection Checks – Instruments
- CHE71 Site Inspection Checks – Switchboards
- CHE72 Site Inspection Checks – Cable ladder/ Tray / Ducts
- CHE136 Site Inspection Checks – Field Equipment

5.15.3 Incoming Equipment Inspections

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

5.15.4 Post Installation Inspection

All installation 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 this specification

5.15.5 Control System Testing

Refer to TMS1733 Control Systems Implementation Standard Technical Specification for quality assurance, testing and commissioning requirements for all control system equipment, including PLCs, HMIs, SCADA and network devices.

5.15.6 Cable Testing – ELV

The relevant Inspection and Test Plans shall detail the exact test requirements for ELV cables. At minimum the following cable tests shall be completed:

- Insulation resistance testing for ELV instrumentation and control cables at a test voltage compatible with the cable being tested
- Point-to-point continuity testing (each core)
- Check terminations are tight and in accordance with termination diagrams. Termination diagrams shall be marked up, signed and issued as evidence
- Cable gland inspection
- Cable label verification

5.15.7 Cable Testing - Low voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for all cables. At minimum the following cable tests shall be completed:

- Insulation resistance testing for LV power and control cables with an insulation test unit at 500V DC or 1000V DC (as applicable) as per AS/NZS 3000
- Point-to-point continuity testing
- Micro-ohm resistance testing for large power cable connections (>70mm^2)
- Torque check for large power cable terminations (>70mm^2)
- Cable gland inspection
- Cable label verification
- Phase connections

5.15.8 Cable Testing – High Voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for all HV cables. At minimum the following cable tests shall be completed:

- Visual inspection for evidence of partial discharge on cables sheaths and terminations where design proposes to retain the cables in service
- Insulation resistance testing of cables in accordance with the recommendations of the cable manufacturer. Insulation resistance shall be tested on the drum before installation and before and after the VLF test
- VLF testing of cables in accordance with the recommendations of the cable manufacturer

- Micro-ohm resistance testing of cable connections before and after termination
- Torque check of HV cable connections (where relevant)
- Cable gland inspection (where relevant)
- Check excessive tension at cable connection points
- Cable label verification
- Screen and armour earthing inspection
- Phase connections

Prior to finalising the ITPs and commencing the HV cable testing proposed cable testing procedures shall be confirmed with the relevant cable vendors to ensure the testing procedures will not damage the cables or void the Manufacturers' warranties.

Existing HV cables to be relocated and retained in service shall be inspected and tested as per above after relocation and before terminating at the new location. All testing shall only be undertaken as per the cable manufacturer's recommendations.

5.15.9 Earth Fault Loop Impedance Testing

The characteristics of protective devices and the earthing system impedance shall be such that, if a fault of negligible impedance occurs anywhere in the electrical installation between an active conductor and a protective earthing conductor or exposed conductive part, automatic disconnection of the supply will occur within times as specified by Section 5.7 of AS/NZS 3000.

Earth fault-loop impedance measurements shall be made for all circuits in accordance with Section 8.3.9 and Section B.4.6 of AS/NZS 3000.

5.15.10 Earth System Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for all earthing systems. At minimum the following tests shall be completed:

- Visual check of earth bars, earth grids and earth electrodes
- Visual check of connection of earth continuity and earth bonding conductors for cable ladders, motors, distribution boards, marshalling panels, process plant/vessels, mechanical equipment and structural steelwork
- Earth continuity checks
- Resistance to earth test of each individual earth electrode
- Step and Touch Potential measurements
- Overall resistance to earth testing of earth grid
- Soil resistivity testing (prior to earth grid design) for Greenfield sites or where significant modification to existing earth grids are required
- Testing shall be undertaken as per the Wenner 4 pin method outlined in AS/NZS 1768
- Testing of instrument earthing interface to any existing earthing system. Tests shall ensure measured resistances are within acceptable levels
    - Intrinsically safe systems shall conform to AS/NZS 60079.11

5.15.11 Power Transformer Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for transformers. At minimum the following inspection and tests shall be completed:

- Check for correct oil level and oil leaks
- Test insulation resistance between windings and from each winding to ground
- Perform primary winding resistance tests on all taps
- Perform secondary winding resistance tests
- Perform ratio and polarity tests on all taps Check all terminations are correct, covers applied and bolts tight
- Perform function tests on all on-board instruments
- Sample and test dielectric breakdown strength and dissolved gasses in insulating oil. Testing shall be undertaken at Urban Utilities' nominated test laboratory
- Monitor for 24 hours after energisation for oil leaks and temperature rise

5.15.12 VSD Testing

The SAT Plan, Commissioning Plan as well as supervision of the site works, shall include:

- Insulation resistance tests
- Secondary injection tests
- Functional test to prove the operation of items
- Adjust all necessary settings, e.g. VSD configuration settings
- Verify the operation of (remote) trips, controls and output signals

5.15.13 Switchboard Testing – Low Voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for each switchboard. At minimum the following inspection and tests shall be completed:

- All tests as per AS/NZS 3017
- Check all labels attached as per label schedule and AS/NZS 3000
- Inspect for damage and missing parts
- Check the IP rating
- Check line out of switchboard for level, vertical alignment and continuity of level between panels. Results shall be within the manufacturer's required tolerances, and no deviation will be accepted
- Check tightness of foundation and structural bolts
- Check tightness of power connection bolts and distribution board bus bar connection bolts
- Check tightness of cable and wire terminations
- Check all earth connections are correct and are connected to the earth grid. Check resistance of main earth cable from earth busbar to earth grid
- High voltage insulation tests on busbars between all phases and from each phase and neutral to earth, and across circuit breaker and switch open contacts using 1000 V test voltage and one minute test duration

- High current μΩ resistance test across incomer cable termination, across incomer switch in closed position, and from incomer to outgoing terminals of power circuits over 150A
- Check phasing of all incoming and outgoing circuits
- Operate each device (switch, CB, contactor, overload etc.) to prove correct operation
- Check operation of door handles, mechanical interlocks, etc and freedom of operation of electrical switches
- Check operation of key interlocks, where installed
- Check fuse holders for damage and fuses for continuity and correct rating
- Check and confirm setting of circuit breakers, thermal overloads, timers etc as per Project Documentation
- Confirm function of all local and remote switching operations

5.15.14 Switchboard Testing – High voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for HV Switchboards. At minimum test as per Section 5.15.13 Switchboard Testing – Low Voltage apply as well as additional testing as follows:

- Confirm nameplate is in place and equipment is within design specification
- Confirm manual operation of switchgear
- Perform contact resistance on Isolators & Earth switches
- Perform micro-ohm resistance test on all bus bars and main circuit connections
- Perform pre Hi Pot insulation resistance tests
- Perform Hi Pot (Withstand) tests
- Perform post Hi Pot insulation resistance tests
- Ensure all indication is correct
- Confirm all electrical indication to local control panel and panel lights
- Confirm all interlocks are operational
- Ensure cable boxes are clean and photos to verify before placing covers on
- Confirm switchgear's physical condition is acceptable
- Partial discharge testing of installed switchboard
- Confirm function of all local and remote switching operations for circuit breakers and isolators

5.15.15 HV Circuit Breaker Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for HV Circuit Breakers. At minimum the following inspection and tests shall be completed:

- Confirm nameplate is in place and equipment is within design specification
- Confirm manual operation of circuit breaker
- Perform contact resistance on circuit breaker (only if circuit breaker is rackable)
- Ensure all indications are correct
- Confirm all interlocks are operational
- Confirm electrical operation of circuit breaker

- Confirm operation of the circuit breaker by secondary injection of the protection scheme
- Perform circuit breaker timing tests
- Perform circuit breaker reduced voltage tests
- Confirm switchgear's physical condition is acceptable

5.15.16 Instrument Transformer Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for instrument transformers. At minimum the following inspection and tests shall be completed:

- Confirm nameplate is in place and equipment is within design specification
- Perform primary insulation resistance tests
- Perform secondary insulation resistance tests
- Perform winding and loop resistance tests
- Perform ratio and polarity tests
- Perform magnetisation curve tests
- Perform secondary loop tests
- Confirm wiring is as per latest schematics
- Confirm polarity of complete secondary circuits
- Perform primary injection metering checks back to protection or metering if applicable
- Confirm physical condition is acceptable

5.15.17 Protection Relay Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for Protection Relays. At minimum the following inspection and tests shall be completed:

- Confirm settings file given is in accordance with Protection Coordination Report
- Secondary injection to confirm correct settings
- Prove protection functions operate correctly via secondary injection including pick-up and drop-off of protection elements
- Prove protection functions operate appropriate outputs via secondary injection
- Prove stability of the Restricted Earth Fault scheme via primary injection of the current transformer
- Confirm mechanical functions from transformer initiate appropriate protection functions
- Ensure all CT links are closed and relay ready to be put in service
- Confirm function of intertrips to and from other protective devices
- Confirm 61850 communications and network functions (if applicable)
- Confirm data communications and system integration with SCADA/PLC system

5.15.18 Motor testing – Low Voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for all motors. At minimum the following motor tests shall be completed:

- Motor insulation resistance testing with a 500V or 1000V DC (as applicable) insulation test unit and minimum one minute test duration
- Resistance testing of PTC devices and thermistors
- Verification of TOL settings
- Verification of correct phasing and phase rotation
- High voltage resistance test across open local isolator contacts (if applicable)
- Resistance test of motor winding for each phase compensate for 25°C
- Earth conductor resistance measurement from motor to MCC earth busbar. Resistance shall not exceed 1Ω
- Full simulation test of all control devices, operating all devices individually and in combination to prove correct operation
- Motor rotation direction test

5.15.19 Motor testing – High Voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for HV motors. At minimum tests as per Section 5.15.18 Motor testing – Low Voltage apply as well as the following additional testing:

- Motor insulation resistance testing with a DC insulation test unit and minimum one minute test duration at voltage specified by manufacturer
- Polarisation Index Tests at 1 minute and 10 minute interval for each phase
- Confirm correct star / delta links fitted if applicable and in the correct configuration

5.15.20 UPS System Testing

Verification shall be undertaken as per the following:

Purpose	Standard	Reference
General & Safety Requirements	AS 62040.1	Section 5.1.7.101 Table 22
Electromagnetic Compatibility	AS 62040.2	Section 5.2 Annex A
UPS-specific tests	AS 62040.3	Section 6.1.6 Table 3

UPS systems serving critical infrastructure (e.g. RRCs, large network sites), shall undergo additional tests to AS 62040.3:

- Stored Energy Time Test
- Restored Energy Time Test

AC UPS systems shall undergo both Factory Acceptance Testing (FAT) and Site Acceptance Testing (SAT). Generally, FAT will demonstrate performance of functional units (system components) and SAT will demonstrate performance of the completed

system, with any AS 62040.3 routine tests or required special tests not completed at FAT being performed as part of SAT.

5.15.21 Battery Chargers, Rectifier, Converter & Inverter Testing

Battery chargers, DC-AC inverters and converters shall be subjected to the normative tests of the standards to which they were manufactured:

Item	Standard
Battery charger	AS 4044
DC-AC inverter	AS 5603
Inverter or Converter	AS 60146.1.1

Where type test certificates to demonstrate these are not available, the tests shall be performed.

Battery bank load, discharge and recharge routine tests shall be performed to confirm the performance of the battery and charger system under a full load and a complete discharge and recharge cycle.

5.15.22 Light and Small Power Installation Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for all light and small power equipment. At minimum the following tests shall be completed:

- All applicable tests as per AS/NZS 3000 and AS 3017
- Polarity tests
- Correct circuit connections
- Normal and emergency horizontal plane illumination levels around operational equipment, along conveyors, walkways and stairs
- Emergency lighting function tests
- RCD injection test

5.15.23 Instrumentation Testing

Field instruments shall be provided with a factory calibration certificate in accordance with the instrument data sheets. Traceable records of the calibration instrument, method used, range, set point, and results shall be supplied.

The following pre-installation requirements shall be complied with to ensure that each instrument has been supplied in accordance with its specifications, is functionally correct and is in working order:

- Instruments shall undergo a proof test as per manufacturer's specifications before installation and the results recorded and signed off accordingly

    - Where a pre-installation test is not specified or where circumstances prohibit the carrying out of a prescribed test, a test method shall be agreed with Urban Utilities prior to installation
- Defective instruments shall be brought to the attention of Urban Utilities. These will normally be returned to the supplier and replaced under warranty
- Urban Utilities' approval in writing shall be obtained prior to any non-standard modifications or adjustments being made

During installation, the following testing requirements apply:

- Check instrument make/model against the data sheets
- Check instrument calibrations against the data sheets
- Check instrument fault settings are as per NAMUR NE43, where supported by the device
- Complete instrument loop tests and complete loop calibration check sheets
- Complete point-to-point pre-commissioning continuity checks between the instrument and electrical equipment, junction boxes, termination panels and I/O cards or distribution boards (where continuity is not covered by loop tests)
- Test for instrument earth loops
- Complete FICs for each instrument
- Complete HA check sheets where an instrument or part of its loop is in a hazardous area
- Functional system tests including all control and safety actions with Operations

The following special requirements apply to particular instrument types:

- Non-contact radar level transmitters shall be range set-up in-situ once installed to account for variations in mounting height from those expected during the design phase.
- Magnetostrictive and guided wave radar level transmitters were ordered factory calibrated for the level bridle centre to centre range. These transmitters shall be range setup to match the latest instrumentation datasheet settings prior to installation.
- HART instruments shall be ranged and configured (instrument serial numbers, tag numbers etc.) using the appropriate calibrators
- Non-SMART pressure instruments shall be calibrated using pressure pump
- Temperature instruments shall be calibrated using decade boxes or temperature baths
- Batteries installed in instruments shall be date stamped with date of instrument installation
- F&G detection devices do not require pre-testing prior to installation, only inspection to check for mechanical defects
- Apart from Fire and Gas detectors, instrument fault and saturation levels shall, where possible, be configured to NAMUR NE43 recommended values, as stated below. Fire and gas detector fault settings shall be configured as per manufacturer's default settings.

Level	4-20 mA Saturation	4-20 mA Alarm (Fault)
Low	3.8 mA	≤ 3.6 mA
High	20.5 mA	≥ 21 mA

5.15.24 Hydraulic and Pneumatic and Impulse Lines

Lines downstream of the process isolation valve shall be flushed and tested.

For testing, lines shall where practicable be disconnected immediately downstream of the process isolation valve. The instruments shall be disconnected from the lines during testing. After first flushing with fresh water, the lines shall be hydrostatically tested for a minimum period of 15 minutes without a fall in pressure. The test pressure shall be 1.5 times the process design pressure (max. allowable working pressure). On satisfactory completion of the tests, the lines shall be purged, cleaned and dried out using oil free dry instrument air. The lines shall then be re-connected at the process isolation valve and at the instrument / panel. Pressure tests shall be recorded on an appropriate recorder and form part of the testing records.

Lines that are fitted with regulators must not be hydrostatic tested with the regulators installed. The regulator diaphragm will be damaged if subjected to the full hydrostatic pressure and therefore the regulator must be removed prior to the test.

5.15.25 Site Acceptance Testing (SAT)

A Site Acceptance Test (SAT) document (test plan/strategy and full complement of test sheets) shall be developed that clearly defines the logical sequence and structured testing of the complete installation (switchboard and all field devices) in accordance with Project Documentation and standard templates. This includes preparation of a switchboard changeover commissioning plan where applicable. SAT documentation shall be site specific and will require Urban Utilities review and approval prior to commencement of each SAT.

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

Note that the Site Acceptance Test Procedure- Checklist (CA17 a to h) shall be completed on the day of every Site Acceptance Test. This checklist shall be reviewed prior to Site Acceptance Testing to ensure all testing can be completed on the scheduled day.

5.15.26 Site Functional Testing

Full Site Functional Testing shall be provided and witnessed by Urban Utilities. These tests include but are not limited to:

- Testing of all field devices from the field through to the Urban Utilities Telemetry Systems Control Room
- Functionality testing of electrically powered mechanical equipment

- Functional testing of switchboard remote operations from the Urban Utilities Telemetry Systems Control Room
- Functionality testing of the backup and changeover system
- Failure modes and process plant recovery
- Functionality testing of the alarms back to the Control Room
- Process control (automatic and manual operation)
- Safety system testing
- Correct function of telemetry and SCADA remote indication at the Urban Utilities Telemetry Systems Control Room for all digital and analogue signals

5.15.27 Settings and Pre-commissioning

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

5.15.28 Failure

Any works or equipment that fails an inspection or test shall be repaired or replaced. Inspections and tests affected by rework shall be repeated.

5.16 Training and Documentation

Documentation shall be furnished in accordance with Project Documentation requirements and the Deliverables Requirements List (DRL).

At minimum the following documentation shall be progressively maintained during Works execution:

- Quality Assurance records including ITPs and the associated check-sheets and test records for all elements of the works
- Cable management records including cable drumming schedules to track the cable quantity utilised and cable quantity remaining for all on-site cable
- Cable traceability records to ensure that all installed cables can be traced to a specific cable drum as supplied from the vendor
- As-built mark-ups of all Project Documentation to reflect the completed installation
- A record of all Urban Utilities accepted changes to Project Documentation
- A record of all Urban Utilities supplied directives or Site Instructions
- A record of all submitted Requests for Information and the associated Urban Utilities responses
- A record of all Urban Utilities accepted Design Deliverables
- Survey records/coordinates that detail the exact route of all buried cable installations and joints

Note: All above documentation shall be maintained at the site and available for Urban Utilities to inspect upon request.

Upon completion of Works the above listed documentation shall be officially submitted to Urban Utilities as well as a complete set of the final signed-off As-built documentation.

5.16.1 Training

A comprehensive training course shall be provided for all electrical equipment, motors, switchboards and protection systems included in the Works.

Training shall include two (2) off training sessions or as otherwise agreed with Urban Utilities. 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 engineers). A scheduled time for training shall be agreed with Urban Utilities within seven (7) days of successful completion of Commissioning works.

The training course may include but not necessarily be limited to the following:

- Introduction and overview of the electrical system including a site walk through
- Description of the electrical power system including functions and features. These shall be supplemented by operations and maintenance manuals
- Description of protection system philosophy
- Switchboard operation
- Protection relay operation and configuration
- Configuration and fault finding of related instrumentation
- Preventative and corrective maintenance procedures
- Engineers and technicians shall be provided a comprehensive site walkthrough and inspection, showing all the electrical and protection 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 Urban Utilities, a separate vendor specific training course shall be provided. This course shall be onsite

Comprehensive course notes shall be provided to accompany the training session which will cover each of the topics.

The course notes shall be prepared and submitted to Urban Utilities 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.

5.16.2 Site Documentation

5.16.2.1 Site Record Drawings

During site works an updated set of site record drawings shall be maintained and made available for inspection by Urban Utilities upon request or continuously via a ShareFile system. It is preferred that these drawings and amendments, including mark-ups, stamps and final signatures, are maintained in a purely digital format such as PDF.

On completion of site works, the red-lined amended drawings are referred to as the "site red-line record drawings", and shall be stamped, signed and dated by the authorised site representative as well as signed as approved by the nominated Electrical RPEQ, then submitted to Urban Utilities.

5.16.2.2 Miscellaneous Documentation

The following documentation shall be maintained up to date during Works execution:

- Quality Assurance records including ITPs 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 Urban Utilities approved changes to Project Documentation
- A record of all Urban Utilities supplied directives or Site Instructions
- A record of all submitted Requests for Information and the associated Urban Utilities responses
- A record of all Urban Utilities approved design deliverables

Upon completion of the Works the above listed documentation shall be officially submitted to Urban Utilities.

5.16.3 As Built Documentation

A set of master drawings, inspection check-sheets, test result records and certificates shall be stored and maintained up to date. During the installation phase, the set of master drawings shall be marked in red with any changes implemented during construction.

Test result records, certificates and drawings with the red-line mark-ups shall be kept securely and will form part of the hand over documentation to Urban Utilities.

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

5.16.3.1 As Built Drawings

The following CAD drawings shall be back drafted to As-Built status:

- Drawing Schedule
- Switchroom layouts
- Equipment location drawings (instruments and electrical equipment)
- General Arrangements for all electrical enclosures (control panels, switchboards and marshalling panels and DBs)
- 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 single line diagrams
- Block diagrams
- All package-plant related As Built documentation inclusive of all "site-specific customisations" for all electrical and loop drawings, I/O lists and termination diagrams

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

All drawings shall be stamped, signed and dated. An RPEQ of appropriate discipline shall certify the As Built mark-ups.

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

An RPEQ shall certify the final As Built CAD drawing revision, with RPEQ initials and number recorded on the CAD drawing.

5.16.3.2 As Built Documents

Electrical Documents as listed in the agreed CHE 486 Deliverables Requirements (DRL) shall be As-Built.

A licensed electrical worker shall certify As-Built documents. An RPEQ shall certify the As-Built design.

All As-Built documents shall be collated into a Dossier to be handed over prior to Practical Completion

5.16.4 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 imported natively or scanned at minimum 600dpi resolution in colour and table of contents provided for quick reference in each document.

The following documents shall be provided:

- Equipment Inspection and Test Reports
- Instrument loop check sheets
- SAT Reports (equipment and protection report)
- Commissioning Report (entire site)
- AS/NZS 3000 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
- Configuration settings for all devices, controllers, protection relays and IEDs that have manually configurable settings by DIP switches, dials, links or equivalent. Typical examples include media converters and low voltage circuit breakers with integrated protection
- Site certification for installation and supply of UTP cables and associated equipment

All handwritten field documentation shall be scanned at high resolution and in colour and delivered to Urban Utilities as electronic PDF files.

All final commissioning, testing and inspection reports shall be collated into a Testing and Commissioning Dossier to be handed over prior to Practical Completion.

Configuration settings shall also be incorporated into the O&M manual master PDF file.

5.16.5 Configuration Files

All configurable electronic devices supplied in the installation shall be provided with the as-commissioned software configuration files and firmware. Programming software, licences and hardware accessories required to fault find and reconfigure the devices shall also be provided.

At completion of the commissioning phase all software configuration files and code shall be uploaded to an Urban Utilities ShareFile link, including but not limited to the following:

- 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 LV and HV protection relay and associated network equipment Configuration Files, including for all IEC 61850 devices
- 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

5.16.6 Operations and Maintenance Manuals

Operations and Maintenance (O&M) Manuals shall be provided for all electrical equipment, switchboards, switchrooms and installations. Manuals shall be separated into logical installation groups, such as by switchroom.

The minimum requirements of AS 1359, AS 2067, AS 2467 and AS/NZS 3000 for operation and maintenance manuals shall be met.

O&M manuals shall be in compliance with SEQ Water Supply and Sewerage Design & Construction Code (SEQ WS&S D&C Code) as well as the Urban Utilities addendum to the SEQ Code, PRO 395 *Urban Utilities Information Requirements*.

Each manual shall include a cover page with the following identifying information:

- Project name
- Asset Tag Name and Title
- Contract / Work Pack number (if applicable) and year of installation
- Company name, address & phone number

All files shall be in one of the following formats to allow Urban Utilities easily access portions of or all the O&M Manual.

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

O&M manuals shall be produced as searchable PDF files bookmarked by chapter. O&M manuals shall be readily printable or exportable by users without intervention. Mismatched portrait/landscape sheets and paper sizes shall be avoided.

Original native files saved to PDF shall be used wherever possible. Scans of printed documents shall not be accepted, except for signature and approval pages which may be colour scanned and merged into the rest of the document.

Original PDF files available from high resolution sources such as vendor web sites shall be used, such as for sub-equipment manuals and data sheets. Original PDFs from these sources shall be merged into the O&M manual master PDF file. Scans of printed documents available as high resolution PDFs shall not be accepted.

Low resolution scans, copies of copies, faxes or otherwise degraded reproductions of documents are not acceptable.

A draft O&M manual shall be provided in electronic format for review before practical completion, including all information. Urban Utilities shall review the documents and provide comments. Following final testing, commissioning and completion of As Built drawings final O&M manual shall be submitted alongside the final Testing and Commissioning Dossier.

The O&M manual for each installation shall include as a minimum:

- Narrative description of the installation and major equipment, by location and tag number
- Operating instructions for each item if equipment, including switchgear, protection relays and motor controllers
- Safety instructions
- Consolidated list of recommended maintenance and servicing schedules for all equipment in the installation
- Preventative maintenance instructions for the overall installation in accordance with AS 2467
- Refer to detailed maintenance instructions for individual equipment in other manuals
- Drawing list showing number, title and revision

- Reference to single line diagrams
- Reference to protection single line diagrams
- Reference to block diagrams
- Reference general arrangement and panel layouts
- Major equipment lists, cross referenced by tag number. Refer to the individual equipment manual for details part lists
- Consolidated list of all spare parts and consumables for the installation, including lubricants and insulation oils
- Details and names of major equipment suppliers
- Label lists
- References by Urban Utilities document number to all As Built drawings, documentation, configuration files, FAT and SAT test reports relevant to the installation and equipment described by that manual. Refer to sections 5.16.3 As Built Documentation, 5.16.4 Final Commissioning, Testing and Inspection Reports and 5.16.5 Configuration Files above
- For high voltage installations, the O&M manual shall also include a detailed description of the normal, emergency and maintenance procedures specific to the installation

5.16.6.1 Generic Manuals

Vendor generic manuals shall be provided with a searchable data sheet attached to the file to indicate the actual equipment supplied.

5.16.7 Hazardous Area Verification Dossier

The site HA Verification Dossier shall be created or updated in compliance with TEM518 *HA Verification Dossier Template* for any package located fully or partially within HAs.

A Schedule of Explosion Protected Equipment shall be produced and maintained for all Ex-rated electrical, instrumentation and telecommunication equipment. The Schedule shall contain a listing and certification details of all equipment. The schedule shall be incorporated into the site Hazardous Area verification dossier.

All new and modification works to equipment installed in hazardous areas shall be audited by a registered HA inspector appointed by the Queensland Electrical Safety Office. As part of the audit process, the HA Auditor shall review the HA Dossier for compliance. The requirements of the HA dossier shall be as per AS/NZS 60079.14 for design and installation and AS/NZS 60079.17 for inspection and maintenance.

The Dossier shall be issued to Urban Utilities prior to the commencement of the project commissioning phase. All equipment decommissioned shall have the relevant information removed from the site HA Dossier. The completeness and accuracy of the HA Dossier shall be verified as part of the installation process.

The Hazardous area dossier and all related hazardous area calculations and design documents shall be certified by a registered Professional Engineer of Queensland (RPEQ) with EEHA competency.

APPENDIX A – ACRONYMS & ABBREVIATIONS

Term	Definition
AC	Alternating Current
ACB	Air Circuit Breaker
mAHD	Metres elevation with respect to Australian Height Datum
ALARP	As Low as Reasonably Practical
ATS	Automatic Transfer Switch
CB	Circuit Breaker
CBF	Circuit Breaker Fail
CDEGS	Current Distribution, Electromagnetic Fields, Grounding and Soil Structure Analysis
CT	Current Transformer
DB	Distribution Board
DC	Direct Current
DOL	Direct On Line
DRL	Deliverables Requirements List
DP	Differential Pressure
EF	Earth Fault
ELV	Extra Low Voltage
EMC	Electromagnetic Compatibility
EMP	Environmental Management Plan
ESW	Earth Switch
EWP	Elevated Work Platform
FAT	Factory Acceptance Test
FIP	Fire Indicator Panel
HVAC	Heating Ventilation and Air Conditioning
HA	Hazardous Area
HVAC	Heating Ventilation and Cooling
IEC	International Electro-technical Commission
I/O	Input / Output
IP	Ingress Protection
IS	Intrinsically Safe
ISO	International Standards Organisation
ITP	Inspection and Test Plan
LBS	Load Break Switch
LCSLCS	Local Control Station
LED	Light Emitting Diode
LFI	Low Frequency Induction
LV	Low Voltage
MCC	Motor Control Centre

Term	Definition
MCCB	Moulded Case Circuit Breaker
MEB	Main Earth Bar
MPPT	Maximum Power Point Tracker
MPU	Motor Protection Unit
MTS	Manual Transfer Switch
NCC	National Construction Code
NMI	National Meter Identifier
MSDS	Material Safety Data Sheet
O&M	Operation and Maintenance
OC	Over current
OEM	Original Equipment Manufacturer
ONAF	Oil Natural Air Forced
PAGA	Public Address and General Alarm
PF	Power Factor
PFC	Power Factor Correction
PLC	Programmable Logic Controller
PPE	Personal Protective Equipment
PQA	Power Quality Analysis
PRV	Pressure Reducing Valve
PSA	Power System Analysis
PV	Photovoltaic
PVC	Polyvinyl Chloride
RCD	Residual Current Device
REF	Restricted Earth Fault
RFI	Radio Frequency Interference
RMU	Ring Main Unit
RRC	Resource Recovery Centre
RTU	Remote Telemetry Unit
QA	Quality Assurance
SAT	Site Acceptance Test
SEF	Sensitive Earth Fault
SCADA	Supervisory Control and Data Acquisition
SLD	Single Line Diagram
SS	Stainless Steel
SWA	Steel Wire Armour
TCS	Trip Circuit Supervision
UCP	Unit Control Panel
UPS	Uninterruptible Power Supply
UV	Ultra-violet

Term	Definition
VLF	Very Low Frequency
VRLA	Valve Regulated Lead Acid
VSD	Variable Speed Drive
VT	Voltage Transformer

APPENDIX B – REFERENCE DOCUMENTS

Document Number	Title
CA-17 c-h	Site Inspection Tests
CHE136	Site Inspection Checks – Field Equipment
CHE68	Site Inspection Checks – Cables
CHE69	Site Inspection Checks - Electric Motors
CHE70	Site Inspection Checks - Instruments
CHE71	Site Inspection Checks – Switchboards
CHE72	Site Inspection Checks – Cable ladder/ Tray / Ducts
FOR279	Site Details & Test Sheet – Electric Motors
FOR893	Instrument Schedule – Template
MP71	Electrical Safety Management Plan
MP183	Hazardous Areas Management Plan
PRO307	Procedure Drafting Guidelines – Contract Requirements
PRO363	WHS Hazard and Risk Management Procedure
PRO395	SEQ Water Supply and Sewerage- D&C Code Asset Information Urban Utilities Addendum
PRO450	Electrical Safety Standard Operating Procedure
PRO521	Safety in Design Standard Operating Procedure
PRO662	Safety in Design Guidelines
PRO752	Deviation from technical Standards Procedure
TEM336	Power System Analysis Guidelines
TEM514	Functional Specification Template for Complex Sites
TEM515	Sewerage Pump Station - Site Specific Functional Specification
TEM518	Hazardous Area Verification Dossier Template
TEM523	Cable Schedule Template
TEM587	Water Booster (MPC) – Site Specific Functional Specification Template
TEM588	PRV – Site Specific Functional Specification Template
TEM590	Water Booster (Lowara) - Site Specific Functional Specification Template
TEM591	Water Booster (VSD) - Site Specific Functional Specification Template
TEM592	Water Pump Station - Site Specific Functional Specification Template
TEM593	Reservoir - Site Specific Functional Specification Template
TMS60	Low Voltage Switchboards
TMS62	Preferred Equipment List – Electrical and Instrumentation
TMS76	Corrosion Protection for Electrical and Mechanical Equipment and Structures

Document Number	Title
TMS78	Typical Switchboard Changeover Commissioning Plan
TMS117	Security, Access, Control and CCTV – Technical Specification
TMS200	PRV – Standard Functional Specification
TMS1185	Distribution Power Transformer (Less than 5MVA) – Technical Specification
TMS1186	HV Switchboards – Technical Specification
TMS1188	Transportable Switchroom – Technical Specification
TMS1733	Control Systems General Technical Specification
TMS1404	HV Motors – Technical Specification
TMS1436	Safety in Design Report Requirements
TMS1589	LV Diesel Generator – Technical Specification
TMS1595	Pipeline and Structures Cathodic Protection – Technical Specification
TMS1621	Typical Pump Station Maximum Demand Template
TMS1625	Dry Type Distribution Transformers – Technical Specification
TMS1631	Vacuum Pump Station – Standard Functional Specification
TMS1639	General Mechanical Works – Technical Specification
TMS1643	Water Booster Site (VSD) – Standard Functional Specification
TMS1645	Packaged Plant EI&C Requirements - Technical Specification
TMS1647	Equipment Tag Naming – Technical Specification
TMS1649	Standard MPC Water Booster – Functional Specification
TMS1650	Fixed Speed Sewage Pumping Station – Standard Functional Specification
TMS1651	Machine Safety Implementation– Technical Specification
TMS1654	Engineering Documentation Naming Requirements
TMS1706	Typical Water Pump Station - Functional specification
TMS1733	Control Systems General Specification
WI58	Arc Flash Assessment and PPE Selection
WI140	Access to LV Electrical Equipment for Visual Inspection

APPENDIX C – TYPICAL DRAWINGS

Typical drawings and other documentation are provided for information only and show an acceptable method, or preferred method of complying with the standards. These are intended to demonstrate minimum content and layout of information and may not represent all the requirements specified in Project Documentation.

Sewage Treatment Plants

Drawing Number	Title
QUU-STD-STP-00	Title Block
QUU-STD-STP-01	Legend
QUU-STD-STP-02	Power Flow Cable Block Diagram
QUU-STD-STP-03	Communication Network Architecture Diagram
Single Line Diagrams	
QUU-STD-STP-04	Protection Line diagram - HV/LV
QUU-STD-STP-05	Main Switchboard Single Line Diagram 400VAC & 230VAC
QUU-STD-STP-06	Area 1 Switchboard Single Line Diagram 400VAC & 230VAC
QUU-STD-STP-07	Area 1 Switchboard Single Line Diagram 400VAC & 230VAC Light and Power
QUU-STD-STP-08	Area 1 Switchboard Single Line Diagram 400VAC & 230VAC UPS DB
QUU-STD-STP-09	Area 1 Switchboard Single Line Diagram 24VDC Distribution Panel 1 of 2
QUU-STD-STP-10	Area 1 Switchboard Single Line Diagram 24VDC Distribution Panel 2 of 2
General Arrangement Drawings	
QUU-STD-STP-20	General Arrangement - Main Switchboard
QUU-STD-STP-21	General Arrangement - Main Switchboard
QUU-STD-STP-22	General Arrangement - Motor Control Centre
QUU-STD-STP-23	General Arrangement - Motor Control Centre
QUU-STD-STP-24	General Arrangement - PLC & Communication Panel
QUU-STD-STP-25	General Arrangement - Outdoor Switchboard
QUU-STD-STP-26	General Arrangement - Local Control Panel
QUU-STD-STP-27	General Arrangement - Construction Details 1 of 2
QUU-STD-STP-28	General Arrangement - Construction Details 2 of 2
Schedules	
QUU-STD-STP-30	Equipment Schedule
QUU-STD-STP-31	Cable Schedule
QUU-STD-STP-32	Label Schedule
Schematic Diagrams	
QUU-STD-STP-40	Schematic Diagram – Incomer ACB
QUU-STD-STP-41	Schematic Diagram - Auto Transfer Switch
QUU-STD-STP-42	Schematic Diagram – UPS
QUU-STD-STP-43	Schematic Diagram - DOL Starter
QUU-STD-STP-44	Schematic Diagram - DOL Reversing Starter
QUU-STD-STP-45	Schematic Diagram - VSD Starter 75kW & Above

Drawing Number	Title
QUU-STD-STP-46	Schematic Diagram - VSD Starter Under 75kW
QUU-STD-STP-47	Schematic Diagram - Motorised Control Valve
QUU-STD-STP-48	Schematic Diagram - Modulating Control Valve
Field Device Connection Diagrams	
QUU-STD-STP-49	Field Device Connection Diagram - Solenoid Valves
QUU-STD-STP-50	Field Device Connection Diagram - Level Switches
QUU-STD-STP-51	Field Device Connection Diagram - Flow Switches
Instrument Loop Diagrams	
QUU-STD-STP-52	Instrument Loop Diagram - Level Transmitter
QUU-STD-STP-53	Instrument Loop Diagram - Flow Transmitter
QUU-STD-STP-54	Instrument Loop Diagram - Level Relay
Termination Diagrams	
QUU-STD-STP-60	Termination Diagram - PLC Layout Diagram (GE Fanuc)
QUU-STD-STP-61	Termination Diagram - Digital Input Card - 16PT (GE Fanuc)
QUU-STD-STP-62	Termination Diagram - Digital Input Card - 32PT (GE Fanuc)
QUU-STD-STP-63	Termination Diagram - Digital Input Card - 32PT (GE Fanuc)
QUU-STD-STP-64	Termination Diagram - Digital Output Card - 16PT (GE Fanuc)
QUU-STD-STP-65	Termination Diagram - Analog Input Card - 12PT (GE Fanuc)
QUU-STD-STP-66	Termination Diagram - Analog Output Card - 8PT (GE Fanuc)
QUU-STD-STP-70	Termination Diagram - Digital Input Card - 32PT (Siemens)
QUU-STD-STP-71	Termination Diagram - Digital Output Card - 16PT (Siemens)
QUU-STD-STP-72	Termination Diagram - Analog Input Card - 8PT (Siemens)
QUU-STD-STP-73	Termination Diagram - Analog Output Card - 8PT (Siemens)
QUU-STD-STP-74	Termination Diagram - DOL Starter
QUU-STD-STP-75	Termination Diagram - DOL Reversing Starter
QUU-STD-STP-76	Termination Diagram - VSD Starter 75 kW & Above
QUU-STD-STP-80	Termination Diagram - VSD Starter Under 75kW
QUU-STD-STP-81	Termination Diagram - Motorised Control Valve
QUU-STD-STP-82	Termination Diagram - Modulating Control Valve
QUU-STD-STP-83	Termination Diagram - PLC Layout Diagram (GE Fanuc)
QUU-STD-STP-84	Termination Diagram - Digital Input Card - 16PT (GE Fanuc)
QUU-STD-STP-85	Termination Diagram - Digital Input Card - 32PT (GE Fanuc)
QUU-STD-STP-00	Title Block
QUU-STD-STP-01	Legend
QUU-STD-STP-02	Power Flow Cable Block Diagram
QUU-STD-STP-03	Communication Network Architecture Diagram
Single Line Diagrams	
QUU-STD-STP-04	Protection Line diagram - HV/LV
QUU-STD-STP-05	Main Switchboard Single Line Diagram 400VAC & 230VAC
QUU-STD-STP-06	Area 1 Switchboard Single Line Diagram 400VAC & 230VAC
QUU-STD-STP-07	Area 1 Switchboard Single Line Diagram 400VAC & 230VAC Light and Power
QUU-STD-STP-08	Area 1 Switchboard Single Line Diagram 400VAC & 230VAC UPS DB
QUU-STD-STP-09	Area 1 Switchboard Single Line Diagram 24VDC Distribution Panel 1 of 2

Drawing Number	Title
QUU-STD-STP-10	Area 1 Switchboard Single Line Diagram 24VDC Distribution Panel 2 of 2
General Arrangement Drawings	
QUU-STD-STP-20	General Arrangement - Main Switchboard
QUU-STD-STP-21	General Arrangement - Main Switchboard
QUU-STD-STP-22	General Arrangement - Motor Control Centre
QUU-STD-STP-23	General Arrangement - Motor Control Centre
QUU-STD-STP-24	General Arrangement - PLC & Communication Panel
QUU-STD-STP-25	General Arrangement - Outdoor Switchboard
QUU-STD-STP-26	General Arrangement - Local Control Panel
QUU-STD-STP-27	General Arrangement - Construction Details 1 of 2
QUU-STD-STP-28	General Arrangement - Construction Details 2 of 2
Schedules	
QUU-STD-STP-30	Equipment Schedule
QUU-STD-STP-31	Cable Schedule
QUU-STD-STP-32	Label Schedule
Schematic Diagrams	
QUU-STD-STP-40	Schematic Diagram – Incomer ACB
QUU-STD-STP-41	Schematic Diagram - Auto Transfer Switch
QUU-STD-STP-42	Schematic Diagram – UPS
QUU-STD-STP-43	Schematic Diagram - DOL Starter
QUU-STD-STP-44	Schematic Diagram - DOL Reversing Starter
QUU-STD-STP-45	Schematic Diagram - VSD Starter 75kW & Above
QUU-STD-STP-46	Schematic Diagram - VSD Starter Under 75kW
QUU-STD-STP-47	Schematic Diagram - Motorised Control Valve
QUU-STD-STP-48	Schematic Diagram - Modulating Control Valve
Field Device Connection Diagrams	
QUU-STD-STP-49	Field Device Connection Diagram - Solenoid Valves
QUU-STD-STP-50	Field Device Connection Diagram - Level Switches
QUU-STD-STP-51	Field Device Connection Diagram - Flow Switches
Instrument Loop Diagrams	
QUU-STD-STP-52	Instrument Loop Diagram - Level Transmitter
QUU-STD-STP-53	Instrument Loop Diagram - Flow Transmitter
QUU-STD-STP-54	Instrument Loop Diagram - Level Relay
Termination Diagrams	
QUU-STD-STP-60	Termination Diagram - PLC Layout Diagram (GE Fanuc)
QUU-STD-STP-61	Termination Diagram - Digital Input Card - 16PT (GE Fanuc)
QUU-STD-STP-62	Termination Diagram - Digital Input Card - 32PT (GE Fanuc)
QUU-STD-STP-63	Termination Diagram - Digital Input Card - 32PT (GE Fanuc)
QUU-STD-STP-64	Termination Diagram - Digital Output Card - 16PT (GE Fanuc)
QUU-STD-STP-65	Termination Diagram - Analog Input Card - 12PT (GE Fanuc)
QUU-STD-STP-66	Termination Diagram - Analog Output Card - 8PT (GE Fanuc)
QUU-STD-STP-70	Termination Diagram - Digital Input Card - 32PT (Siemens)
QUU-STD-STP-71	Termination Diagram - Digital Output Card - 16PT (Siemens)
QUU-STD-STP-72	Termination Diagram - Analog Input Card - 8PT (Siemens)

Drawing Number	Title
QUU-STD-STP-73	Termination Diagram - Analog Output Card - 8PT (Siemens)
QUU-STD-STP-74	Termination Diagram - DOL Starter
QUU-STD-STP-75	Termination Diagram - DOL Reversing Starter
QUU-STD-STP-76	Termination Diagram - VSD Starter 75 kW & Above
QUU-STD-STP-80	Termination Diagram - VSD Starter Under 75kW
QUU-STD-STP-81	Termination Diagram - Motorised Control Valve
QUU-STD-STP-82	Termination Diagram - Modulating Control Valve
QUU-STD-STP-83	Termination Diagram - PLC Layout Diagram (GE Fanuc)
QUU-STD-STP-84	Termination Diagram - Digital Input Card - 16PT (GE Fanuc)
QUU-STD-STP-85	Termination Diagram - Digital Input Card - 32PT (GE Fanuc)

Network Sites

Drawing Number	Title
General	
486/5/5-0171-561	Field Instrumentation Installation Details Level Probes
486/5/25-0003-342	Valve Pit Pressure Sensor Installation and Details
486/5/7-0470-024	Field Instrumentation Installation Details
486/4/7-0032-016	Water Meters General Arrangement

Site Description	Electrical Drawings	Functional Specification	RTU Code
Trio Radio Repeater	√	NA	NA
Reservoir – Up to 2 off Reservoirs and Inlet Valves	√	√	√
Sewage Pump Station (Full option switchboard)	√	√	√
Sewage Pump Station (Reduced option switch board)	√	√	√
Sewage Pump Station (Low Risk switchboard)	√	√	√
Sewage Pump Station (Form 1 switchboard)	√	√	√
Vacuum Sewage Pump Station	√	√	√
Water Booster – Lowara	√	√	√
Water Booster – MPC	√	√	√
Water Booster – VSD	√	√	√
Water Monitoring Stations- PRV, FM, PG, Valves	√	√	√

Site Description	Electrical Drawings	Functional Specification	RTU Code
Water Pump Station	√	√	√

√ - Available on request from Urban Utilities

NA – Not Available