# ELECTRICAL INSTALLATION

## TMS1200 - STANDARD TECHNICAL SPECIFICATION

Revision Table

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| **03** | 24/05/2021 | Major Revision | Cesar Mendoza | Tim Campbell | Craig Moir | Joe Otter |

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## COPYRIGHT

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# Contents

# 1 INTRODUCTION

This specification details the minimum requirements for design, manufacture, testing, installation and commissioning of electrical equipment installed on Urban Utilities facilities.

## 1.1 Scope

This Specification shall be read in conjunction with the General and Specific Conditions of Contract. The Contractor shall be responsible for the supply of all labour, equipment, and materials necessary to construct the works in accordance with the Project Documentation. The Contract may exclude the supply only of items specified as being supplied by Urban Utilities.

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

## 1.2 Definitions

In this document, the following definitions apply:

| Term | Definition |
|---|---|
| **Project Documentation** | Governing technical documents for the specific item(s) for the specific works included or referenced in the Contract |
| **Contractor** | The entity responsible for the delivery of the required infrastructure. 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. |

## 1.3 Acronyms and Abbreviations

| Term | Definition |
|---|---|
| **CEMP** | Construction Environment Management Plan |
| **DC** | Direct Current |
| **DRL** | Deliverables Requirements List |
| **ELV** | Extra Low Voltage |
| **FAT** | Factory Acceptance Test |
| **FIP** | Fire Indicator Panel |
| **EMC** | Electro-Magnetic Compatibility |
| **EWP** | Elevated Work Platform |
| **HDD** | Horizontal Directional Drilling |
| **HVAC** | Heating Ventilation and Air Conditioning |
| **IEC** | International Electro-technical Commission |
| **I/O** | Input / Output |
| **IP** | Ingress Protection |
| **ISO** | International Standards Organisation |
| **ITP** | Inspection and Test Plan |
| **LED** | Light Emitting Diode |
| **LV** | Low Voltage |

| Term | Definition |
|---|---|
| **LCS** | Local Control Station |
| **MCC** | Motor Control Centre |
| **MEB** | Main Earth Bar |
| **NCC** | National Construction Code |
| **NMI** | National Meter Identifier |
| **MSDS** | Material Safety Data Sheet |
| **O&M** | Operation and Maintenance |
| **OEM** | Original Equipment Manufacturer |
| **PLC** | Programmable Logic Controller |
| **PPE** | Personal Protective Equipment |
| **PTC** | Positive Temperature Coefficient |
| **PVC** | Polyvinyl Chloride |
| **RCD** | Residual Current Device |
| **RFI** | Radio Frequency Interference |
| **RTU** | Remote Telemetry Unit |
| **QA** | Quality Assurance |
| **SAT** | Site Acceptance Test |
| **SLD** | Single Line Diagram |
| **SWA** | Steel Wire Armour |
| **TOL** | Thermal Overload |
| **UPS** | Uninterruptible Power Supply |
| **UV** | Ultra-violet |
| **VLF** | Very Low Frequency |
| **VSD** | Variable Speed Drive |

## 1.4 Reference Documents

| Document Number | Title |
|---|---|
| FOR279 | Site Details & Test Sheet – Electric Motors |
| CA-17 c-h | Site Inspection Tests |
| 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 |
| CHE136 | Site Inspection Checks – Field Equipment |
| MP71 | Electrical Safety Management Plan |
| MP183 | Hazardous Area Management Plan |
| PRO307 | Procedure Drafting Guidelines – Contract Requirements |
| PRO395 | SEQ Water Supply and Sewerage- D&C Code Asset Information Urban Utilities Addendum |
| PRO662 | Safety in Design SOP |
| SWMS2 | Safe Work Method Statement Confined Space Entry |
| TEM336 | Power System Analysis Guidelines |
| TEM518 | Hazardous Area Verification Dossier Template |
| TMS60 | Low Voltage Switchboards - Technical Specifications |
| TMS62 | Preferred Equipment List – Electrical and Instrumentation |

| Document Number | Title |
|---|---|
| TMS76 | Corrosion Protection for Electrical and Mechanical Equipment and Structures |
| TMS78 | Typical Switchboard Changeover Commissioning Plan. |
| TMS117 | Security, Access, Control and CCTV – Technical Specification |
| TMS1151 | Preferred Equipment List – Control Systems |
| TMS1185 | Distribution Power Transformers (Less than 5MVA) – Technical Specification |
| TMS1186 | High Voltage Switchboards – Technical Specification |
| TMS1187 | AC Uninterrupted Power Supply – Technical Specification |
| TMS1188 | Transportable Switchroom – Technical Specification |
| TMS1201 | Instrumentation Installation Specification |
| TMS1202 | Control System Implementation - Technical Specification |
| TMS1203 | General Requirements for Installation of Electrical Equipment in Hazardous Areas |
| TMS1221 | DC Power Supply Systems – Technical Specification |
| TMS1222 | Control Panels – Technical Specification |
| TMS1404 | HV Motors – Technical Specification |
| TMS1406 | LV Variable Speed Drives – 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 |
| TMS1637 | LV Motors – Technical Specification |
| TMS1639 | General Mechanical Works – Technical Specification |
| TMS1645 | Packaged Plant Electrical, Instrumentation and Control System Requirements - Technical Specification |
| TMS1647 | Equipment Tag Naming – Technical Specification |
| TMS1648 | Electrical, Instrumentation and Control Systems Design Criteria – Technical Specification |
| TMS1651 | Machine Safety Implementation– Technical Specification |
| WI58 | Arc Flash Assessment and PPE Selection |

# 2 STANDARDS & REGULATIONS

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

Where conflict exists between different Codes, Standards or Regulations, the most onerous conditions of specification shall apply unless accepted otherwise in writing by Urban Utilities.

No deviations from the provisions of the relevant standard are permitted without first obtaining agreement in writing from Urban Utilities.

Standards and regulations relevant to the works include but are not necessarily limited to the following:

## 2.1 Australian Standards

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

| Standard | Title |
|---|---|
| ISO/IEC 80000 | Quantities and Units |
| AS/NZS 1020 | Control of undesirable static electricity |
| AS 1192 | Electroplated coatings, nickel and chromium. |
| AS/NZS 1158.3.1 | Lighting for roads and public spaces Pedestrian area (Category P) lighting - Performance and design requirements |
| AS 1275 | Metric screw threads for fasteners |
| AS 1284 | Electricity metering – All Parts |
| AS 1307.2 | Surge arresters – Metal-oxide surge arresters without gaps for A.C. systems |
| AS 1319 | Safety signs for the occupational environment |
| AS 1324 | Air filters for use in air conditioning and general ventilation – All Parts |
| AS 1345 | Identification of the contents of piping, conduits and ducts. |
| AS 1428 | Design for access and mobility – All Parts |
| AS/NZS 1429.1 | Electric cables- polymeric insulated – For working voltages 3.6kV up to and including 36kV |
| AS 1530 | Methods for fire tests on building materials, components and structures – All Parts |
| AS/NZS 1554 | Structural steel welding – All Parts |
| AS 1603 | Automatic fire detection and alarm systems – All Parts |
| AS 1627 | Metal finishing – Preparation and pre-treatment of surfaces – All Parts |
| AS 1657 | Fixed platforms, walkways, stairways and ladders |
| AS/NZS 1660 | Test methods for electric cables – All Parts |
| AS 1668 | The use of ventilation and air-conditioning in buildings – All Parts |
| AS 1670 | Fire detection, warning, control and intercom systems – All Parts |
| AS/NZS 1680 | Interior and workplace lighting - All Parts |
| AS 1682 | Fire, smoke and air dampers – All Parts |
| AS 1767 | Insulating liquids – All Parts |
| AS/NZS 1768 | Lightning protection |

| Standard | Title |
|---|---|
| AS 1789 | Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch process) |
| AS/NZS 1841 | Portable fire extinguishers – All Parts |
| AS 1897 | Fasteners – Electroplated coatings |
| AS 1905 | Components for the protection of openings in fire resistance walls – All Parts |
| AS/NZS 2053 | Conduits and fittings for electrical installations – All Parts |
| AS 2067 | Substations and high voltage installations exceeding 1 kV A.C |
| AS 2239 | Galvanic (sacrificial) anodes for cathodic protection |
| AS/NZS 2293 | Emergency escape lighting and exit signs for buildings – All Parts |
| AS/NZS 2312 | Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – All Parts |
| AS 2374.1.2 | Power transformers – Minimum energy performance standard (MEPS) requirements for distribution transformers |
| AS 2374.8 | Power transformers – Application guide |
| AS 2467 | Maintenance of electrical switchgear |
| AS 2700 | Colour standards for general purposes |
| AS 2832 | Cathodic protection of metals – All Parts |
| AS/NZS 2857 | Timber drums for insulated and bare cables |
| AS 2865 | Safe working in a confined space. |
| AS/NZS 3000 | Electrical installations (known as the Wiring Rules) |
| 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 |
| AS/NZS 3010 | Electrical installation – Generator sets |
| AS 3011 | Electrical installations – Secondary batteries installed in buildings – All Parts |
| AS/NZS 3012 | Electrical Installations – Constructions and demolitions sites |
| AS/NZS 3017 | Electrical installations—Verification guidelines |
| AS/NZS 3100 | Approval and test specification - General requirements for electrical equipment |
| AS/NZS 3111 | Approval and test specification- Miniature overcurrent circuit breakers |
| AS 3133 | Approval and test specification – Air break switches |
| AS/NZS 3190 | Approval and test specification – Residual current devices (current-operated earth-leakage devices) |
| AS/NZS 3808 | Insulation and sheathing materials for electric cables |
| AS/NZS 3863 | Galvanised mild steel wire for armouring electric cables |
| AS 3894 | Site testing of protective coatings – All Parts |
| AS 3983 | Metal drums for insulated and base electric cables |
| AS 4024 | Safety of machinery – All Parts |
| AS 4070 | Recommended practices for protection of low voltage electrical installation and equipment in MEN systems for transient over voltages |
| AS 4214 | Gaseous fire-extinguishing systems |
| AS 4312 | Atmospheric corrosivity zones in Australia |
| AS/NZS 4325.1 | Compression and mechanical connectors for Power Cables - Test methods and requirements |

| Standard | Title |
|---|---|
| AS 4398 | Insulators- Ceramic or glass- Station post for indoor and outdoor use – Voltages greater than 1000V AC – All Parts |
| AS 4428 | Fire detection, warning, control & intercom systems – All Parts |
| SA TS 60815 | Selection and dimensioning of high-voltage insulators intended for use in polluted conditions |
| AS/NZS 4509 | Stand-alone power systems – All Parts |
| AS/NZS 4534 | Zinc and zinc/aluminium-allow coatings on steel wire |
| AS/NZS 4680 | Hot-dip galvanised (zinc) coatings on fabricated ferrous articles |
| AS/NZS 4761.1 | Competencies for working with electrical equipment for hazardous areas (EEHA) – Competency Standards |
| AS/NZS 4777 | Grid-connections of energy systems via inverters – All Parts |
| AS/NZS 4792 | Hot-dip galvanised (zinc) coatings on ferrous hollow sections, applied by a continuous or specialised process |
| AS/NZS 4805 | Accessories for electric cables-Test requirements – Power cables from 3.6kV up to 36kV – All Parts |
| AS/NZS 4853 | Electrical hazards on metallic pipelines |
| AS/NZS 5000 | Electric Cables- Polymeric insulated – All Parts |
| AS/NZS 5033 | Installation of photovoltaic (PV) arrays |
| AS 6183 | Fire protection equipment – Carbon dioxide extinguishing systems for use on premises – Design and installation |
| AS 60034 | Rotating electrical machines – All Parts |
| AS 60038 | Standard voltages |
| AS 60060.3 | High-voltage test techniques Part 3: Definitions and requirements for on-site testing |
| AS/NZS 60076 | Power transformers – All Parts |
| AS/NZS 60079 | Explosive atmospheres – All Parts |
| AS/NZS 60137 | Insulated bushings for alternating voltages above 1000 V |
| AS 60146 | Semiconductor converters – General Requirements and Line Commutated Converters |
| AS/NZS 60214.1 | Tap-changers – Performance requirements and test methods |
| AS/NZS 60265.1 | High voltage switches Part 1: Switches for rated voltages above 1kV and less than 52kV |
| AS 60422 | Mineral insulating oils in electrical equipment – Supervision and maintenance guidance |
| AS 60470 | High-voltage alternating current contactors and contactor-based motor-starters |
| AS 60529 | Degrees of Protection Provided by Enclosures (IP Code) |
| AS 60849 | Sound systems for emergency purposes |
| AS/NZS IEC 60947 | Low-voltage switchgear and control gear – All Parts |
| AS 61000 | Electromagnetic compatibility (EMC) – All Parts |
| AS IEC 61131 | Programmable controllers – 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/NZS 61558.1 | Safety of power transformers, power supplies, reactors and similar products – general requirements and tests |
| AS 61869 | Instrument transformers – All Parts |

| Standard | Title |
|---|---|
| AS 62040 | Uninterruptible power supply (UPS) – All Parts |
| AS/NZS 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 CISPR 11 | Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurements |
| CCM | Communications Cabling Manual (CCM) Volume 2 - 2007 |
| (ENA) EG 1-2006 | Substation Earthing Guides |

## 2.2 International Standards

| Standard | Title |
|---|---|
| IEC 60034 | Rotating electrical machines – All Parts |
| IEC 60038 | Standard voltages |
| IEC 60050 | International Electro-technical Vocabulary – All Parts |
| IEC 60051 | Direct acting indicating analogue electrical measuring instrument and their accessories – All Parts |
| IEC 60228 | Conductors of insulated cables |
| IEC 60255 | Measuring relays and protection equipment – All Parts |
| IEC 60269 | Low voltage fuses – All Parts |
| IEC 60282 | High voltage fuses |
| IEC 60296 | Fluids for electro-technical applications – Unused mineral insulating oils for transformers and switchgear |
| IEC 60332 | Tests on electric and optical fibre cables under fire conditions – All Parts |
| IEC 60417 | Graphical symbols for diagrams – IEC database edition |
| IEC 60445 | Basic and safety principles for man-machine interface, marking and identification - Identification of equipment terminals, conductor terminations and conductors |
| IEC 60502 | Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) – All Parts |
| IEC 61158 | Industrial communication networks - Fieldbus specifications – All Parts- |
| IEC 61243-5 | Live working - Voltage detectors - Part 5: Voltage detecting systems (VDS) |
| IEC TR 61641 | Enclosed low-voltage switchgear and controlgear assemblies - Guide for testing under conditions of arcing due to internal fault |
| IEC 61643 | Low-voltage surge protective devices – All Parts |
| IEC 61850 | Communications networks and systems for power utility automation – All Parts |
| IEC 61914 | Cable cleats for electrical installations |
| IEC 62444 | Cable glands for electrical installations |
| IEC 62443 | Security for industrial automation and control systems.– All Parts |
| IEC 62541 | OPC unified architecture – all parts |
| IEC TS 62941 | Terrestrial photovoltaic (PV) modules - Guideline for increased confidence in PV module design qualification and type approval |
| IEEE 519 | Recommended practices and requirements for harmonic control in electrical power systems |
| IEEE Std 1815 | Electric power systems communications – Distributed network protocol (DNP3) |
| IEEE 802.3 | Ethernet |

| Standard | Title |
|---|---|
| ISO 13849 | Safety of machinery - Safety-related parts of control systems – All Parts |
| ISO 9001 | Quality management systems – Requirements |
| NFPA 70E:2021 | Standard for electrical safety in the workplace |

## 2.3 Regulations and Codes

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

- Queensland Electricity Act (1994)
- Queensland Electricity Regulations (2006)
- Queensland Work Health and Safety Act 2011
- Queensland Work Health and Safety Regulations 2011
- Queensland Work Health and Safety Codes of Practice
- Queensland: Environmental Protection Act - 1994 and Amendment Act – 1997
- Queensland Electrical Safety Act 2002 and its latest amendments
- Queensland Electrical Safety Regulations 2013
- Queensland Electrical Safety Code of Practice 2013
- Queensland Professional Engineers Act 2002
- Queensland Professional Engineers Regulation 2003
- Queensland Workers' Compensation and Rehabilitation Act 2003 and Amendment Act 2015
- National Construction Code 2016, volumes 1, 2, 3 and The Guide
- Australian Work Health and Safety Act 2011
- Australian Work Health and Safety Regulation 2011
- Australian Work Health and Safety Codes of Practice 2015
- 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

## 2.4 Units and Language

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

## 2.5 Exceptions

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

If during the course of design, planning or installation, circumstances arise wherein Urban Utilities agrees that this Specification cannot be complied with or if an innovative or alternate approach is proposed, the proposed deviation shall be submitted to Urban Utilities in writing for approval. This shall include the following:

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

Backing information shall be sufficient for an engineering assessment of the deviation to be carried out. If insufficient information is provided, Urban Utilities may reject the proposal and request additional information.

# 3 GENERAL REQUIREMENTS

## 3.1 Operation and Design Life

Unless otherwise stated in Project Documentation, electrical installations shall be designed for a minimum life of 20 years continuous service in the environment and for the duty specified herein and in the relevant Project Documentation.

## 3.2 Location and Environmental Conditions

Electrical equipment shall be designed and rated for the environmental conditions as specified on the Project Documentation.

Selection of electrical 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.

When installing equipment in a corrosive environment, consideration shall be given to the environment and 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.

## 3.3 Operating Parameters

| Parameter | Value |
|---|---|
| System voltage (HV) | 11 kV ±5% |
| 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 |

## 3.4 Personal Protective Equipment

The Contractor shall ensure all workers accessing live electrical equipment at voltages levels exceeding ELV shall comply with the minimum requirements of NFPA 70E or alternatively comply with WI58 Arc Flash Hazard Assessment and PPE Selection. Any departures from this work instruction or NFPA 70E shall only be permitted where accepted in writing by Urban Utilities. A risk assessment and supporting information shall be submitted with the request for any departures.

## 3.5 Urban Utilities' Site Induction Training

All personnel must attend a Site Induction Training course managed, arranged and coordinated by Urban Utilities, prior to being granted site access by Urban Utilities.

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

Urban Utilities will administer the Site Induction Training course at no cost, unless special training sessions are requested at short notice. The cost of attendance at the Site Induction Training by the Contractor's operatives shall be the responsibility of the Contractor.

### 3.5.1 Lock-Out/Tag-Out (LOTO)

PRO379 Energy Lock Out Tag Out Procedure applies to all Urban Utilities employees and contractors on Urban Utilities controlled workplaces. Contractors are to adhere to the requirements of this procedure unless a contract detailing control of a workplace has nominated a principal contractor other than Urban Utilities.

Contractor operatives accessing live electrical equipment 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.

## 3.6 Workmanship and Personnel

Personnel engaged in the construction of electrical installations shall be accredited, suitably experienced, competent and skilled in the particular 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.

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

Urban Utilities' Representative 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.

## 3.7 Rectification of Existing Installations

The Contractor is responsible for ensuring that the electrical equipment and installation is electrically safe in accordance with AS/NZS 3000 and the Queensland Electrical Safety Act.

If the Contractor discovers out of scope equipment, circuits or electrical installations that cannot be safely energised or are otherwise electrically unsafe, the Contractor shall notify Urban Utilities, describe the issue in detail and propose a solution. Contractors encountering these situations shall seek direction from Urban Utilities.

## 3.8 Weather and Ingress Protection

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

Equipment containing wiring or devices that are 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 un-protected exposure to the weather, including direct sunlight and hose-down cleaning. Where specified in the Project Documentation weather hoods and/or sun-shades shall be provided for UV and weather protection.

## 3.9 Construction Design

Construction design comprises any required design detail not captured in Project Documentation or standard drawings. It shall capture the final element of design required to complete the electrical installation and shall be completed by the Contractor. All such design works shall complement and not contradict or modify the intent of the design as provided in the Project Documentation.

All construction design undertaken by the Contractor shall be approved by an RPEQ and shall be reviewed and accepted by Urban Utilities' Representative before commencing installation works associated with the design.

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

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

- Final equipment mounting location
- Final equipment mounting arrangements and brackets
- Methods of securing equipment (e.g. bolts, screws, fixings, anchors, grouting)
- Earthing and bonding of equipment, including earth tails and connections to structures, concrete reinforcement and earth grids where required
- Cable ladder and conduit/pipe sizing
- Cable ladder and conduit/pipe routing

- Cable ladder and cable/conduit support brackets
- Above ground cable protection
- Cable glands and cable terminations
- Underground cable trench cross-sectional layout and dimensions
- Underground cable trench routing (including the coordination of these works)
- Building penetrations and sealing
- Junction box selection and sizing
- Equipment stands and sunshades
- Label types and fixing methods for cables and equipment

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

## 3.10 Use of Correct Tools

All equipment and tools to be utilised in the 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.

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

## 3.11 Mounting Brackets and Supports

The 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' Representative. For any brackets and supports that are not defined in these documents, the Contractor shall design and submit a proposed arrangement to Urban Utilities' Representative for approval. No procurement, fabrication or installation shall be completed without the receipt of approval from Urban Utilities' Representative.

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 unless specifically detailed in the Project Documentation. 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.

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

## 3.12 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 unless specified otherwise in the Project Documentation. 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]<br>Expansion bolts |
| Concrete | Screws with plastic or metal fibre expansion plugs[1]<br>Expansion bolts<br>Grouted hold-down bolts<br>Chemical Anchors |
| Timber | Screws<br>Bolts |
| Metal | Screws<br>Bolts<br>Welding<br>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.

## 3.13 Cutting, Drilling and Welding

All 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.

All 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' Representative, except as detailed in the Project Documentation.

Pre-cast concrete slabs or tilt-up panels shall not be cut or drilled without approval from Urban Utilities' Representative, except as detailed in the Project Documentation. Exposed reinforcement structural steel in concrete slabs shall be sealed with an accepted rust prevention coating system.

All 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.

## 3.14 Sealing Penetrations and Conduits

All 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 |
| 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 Representative | 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' Representative. Cement grout shall meet the requirements of TMS 1439 *Concrete Structures*. 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 the TMS1203 *General Requirements for Installation of Electrical Equipment in Hazardous Areas*, shall be accepted by Urban Utilities' Representative and shall be suitably certified as required and in accordance with the manufacturer's specifications.

## 3.15 Setting Out Works

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

Following this assessment, a proposed exact installation location shall be submitted to Urban Utilities' Representative 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 the Project Documentation

## 3.16 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' Representative 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 by the Contractor and accepted by Urban Utilities' Representative prior to commencement of the works.

## 3.17 Foundations and Concrete Structures

The Contractor shall ensure that any items to be cast into the concrete (i.e. rag bolts, conduits, earthing connections etc) are 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 TMS 1439 for details regarding concrete structures.

## 3.18 Coatings

### 3.18.1 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*.

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.

### 3.18.2 Hot Dip Galvanising

Hot dip galvanised items shall, as a minimum, comply with the requirements of AS/NZS 4680.

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.

## 3.19 Care and Maintenance

All site personnel shall be fully aware of and comply with the requirements for good housekeeping on the site. The Contractor shall ensure this is the case for personnel within their control.

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

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

All flammable debris shall be removed prior to working with naked flame tools, welding, cutting or grinding equipment. Equipment shall be protected from damage by grinding, drilling, 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.

Particular attention is drawn to the need for care when cutting and removing the armouring on braided cables within switchgear enclosures.

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

Tools and loose items shall not be left or stored inside equipment or switchboard cubicles.

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

be inspected for internal moisture and adequately dried-out prior to energisation. All 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 and the like) from site all elevated cable pathways shall be inspected to ensure all cable pulling equipment and debris is removed, cable covers are properly installed and equipotential earths applied.

## 3.20 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*.

## 3.21 Galvanic Corrosion

For all electrical installations suitable measures as accepted by Urban Utilities' Representative shall be adopted to minimise the effects of electrolytic corrosion such as:

- Use of stand-off washers when mounting equipment of dissimilar metals onto structure
- 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

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

## 3.22 Environmental Obligations

All works shall be in accordance with the Contractor's accepted Construction Environmental Management Plan (CEMP).

The Contractor shall develop a CEMP in accordance with the objectives and requirements of the project environmental conditions of approval.

The CEMP shall provide detailed information on how the Contractor will manage the site works 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 CEMP, including (but not limited to):

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

# 4 MATERIALS AND EQUIPMENT

## 4.1 Supply

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

All Contractor supplied materials and equipment shall be of manufacturer, type and model as specified in the Project Documentation. For all non-specified equipment, the TMS62 Preferred Equipment List – Electrical shall nominate the preferred suppliers and/or equipment. These requirements shall not be deviated from without prior written approval from Urban Utilities' Representative. Where the materials are not specified, the Contractor may offer standard materials suitable for the application, environment and operating/design conditions. Non-specified equipment shall be of the same type, grade and quality as similar items specified in the Project Documentation. Corresponding parts of similar equipment shall where possible be interchangeable.

All materials and equipment shall be of standard manufacture and readily available from suppliers unless specified otherwise in the Project Documentation. All equipment supplied shall be sourced from local OEM (Original Equipment Manufacturer) Authorised Distributors within Australia.

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

All materials shall be free from:

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

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

## 4.2 Handling, Storage & Preservation

All materials shall be stored, handled and preserved in accordance with the relevant Project Documentation.

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

The Contractor shall be responsible for the safety, security and preservation of all equipment and materials received for the duration of the Contract. All such equipment and materials shall be stored in a suitable location and environment in accordance with the supplier's recommendations to prevent any damage, deterioration or corrosion prior to installation (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.

## 4.3 Surplus and Scrap Materials

Any 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' Representative.

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

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

## 4.4 Hazardous Areas

Refer to TMS1203 *General Requirements for Installation of Electrical Equipment in Hazardous Areas*.

# 5 EQUIPMENT INSTALLATION AND DECOMMISIONING

## 5.1 General

All materials and installation arrangements shall be in accordance with the standard installation documentation unless otherwise accepted by Urban Utilities' Representative. For any equipment or installations that have not been defined in these documents, the Contractor shall design and submit a proposed arrangement (as per section 3.9) to Urban Utilities' Representative for approval. No procurement, fabrication or installation shall commence without the receipt of approval from Urban Utilities' Representative.

The Contractor shall ensure that the suppliers' installation recommendations are 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' Representative for resolution.

## 5.2 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' Representative 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' Representative immediately.

The Contractor shall install 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)

On-site, the 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 by the Contractor.

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 Suppliers 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 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.

The outdoor condenser units shall be installed and fixed into position on rubber feet and as per the supplier's recommendation. The 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.

The refrigerant pipework shall be installed by a qualified air conditioning fitter. All refrigerant pipework shall be adequately supported and braced and installed clear of ground level. The 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.

## 5.4 Switchgear and Switchboards

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

Switchboards supplied in a number of shipping sections shall be carefully aligned and joined together at all points from which the 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 the 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.

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

### 5.4.1 Site Installation

Where outdoor switchboards are to be 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' Representative. At sewage pump station sites, a hygroscopic barrier shall be installed between the grout and the switchboard mountings.

### 5.4.2 Consumer Mains and Metering

As part of the switchboard changeover strategy the Contractor shall make all necessary arrangements 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, the Contractor shall consult with Urban Utilities Representative 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, the Contractor shall also forward a copy of the completed and signed form to the Urban Utilities Representative.

### 5.4.3 Switchboard Changeover

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

The Contractor shall submit, for each site, a draft version of the switchboard Changeover Commissioning Plan at least ten (10) working days prior to the commencement date for Site Acceptance Testing. *TMS78 Sample Typical Changeover Commissioning Plan* sets the minimum standards for the switchboard Changeover Commissioning Plan documentation.

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

## 5.5 Floor and Wall Mounted Panels and Equipment

Miscellaneous floor mounted equipment such as control panels, VSDs, cabinets, battery chargers and UPSs 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<br>Brackets fixed to structural steel |

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

## 5.6 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 boards/panels shall be from the bottom only, unless otherwise accepted in writing by Urban Utilities' Representative.

## 5.7 Transformer Compounds

Where fire walls are required around transformer compounds, these shall be in accordance with AS 2067. All cable penetrations within the fire walls are to be cast in. No drilling or cutting penetrations in these fire walls shall be permitted. The Contractor shall be responsible for the coordination of the necessary electrical services penetrations in any pre-cast fire walls. All penetrations through the fire walls shall be fire rated upon completion of the works.

## 5.8 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.

All 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' Representative. Any other auxiliary equipment removed for transport shall be fitted in accordance with the Supplier's instructions.

The Contractor shall supply oil for flushing and final filling. 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' Representative 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.

The Contractor shall check phasing before connections are made.

Prior to lifting each transformer into position, a lifting study shall be completed and submitted to Urban Utilities' Representative for approval. The exact location and orientation of each transformer shall be as detailed in the relevant transformer drawings. The 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' Representative immediately.

The cable termination boxes shall remain sealed prior to the installation of the cables to prevent the ingress of dust.

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.

## 5.9 Motors and Generators

The 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. The insulation testing shall be undertaken so as to prevent any damage to these devices.

The Contractor shall ensure that the correct phase connections for the desired motor rotation direction are made during 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.

## 5.10 UPS, Batteries and Chargers

UPS, batteries and battery chargers shall be installed in accordance with the drawings and the supplier's instructions.

All links and connections shall be checked for tightness.

All 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.

## 5.11 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, the positioning and mounting arrangements of local motor control equipment shall be as defined in the Project Documentation. For instances where the location is not defined, it shall be installed in a position agreed with Urban Utilities' Representative 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 the 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 the LCS equipment and installation configuration shall be in accordance with TMS1203 *General Requirements for Installation of Electrical Equipment in Hazardous Areas*.

## 5.12 Field Junction Boxes

Large field junction boxes (i.e. those equipped 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. All 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 the 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 manufactured by the Contractor
- 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.

## 5.13 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 the Project Documentation.

The Contractor shall ensure that any cathodic protection wiring which exists within wet wells remains in-situ during the switchboard changeover and removal of the existing switchboard.

The Contractor shall be responsible for 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 (unless specifically determined otherwise by Urban Utilities in project documentation). 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, unless specified otherwise in project documentation. 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.

# 6 CABLES

## 6.1 General

The Project Documentation cable schedules and/or drawings shall define the exact cable type to be installed for each application.

Generally 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 unless otherwise noted in the cable schedules specified in the Project Documentation.

All 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.

All 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.

All 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 TMS1203 *General Requirements for Installation of Electrical Equipment in Hazardous Areas* for the additional requirements for cables in hazardous areas.

## 6.2 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 |

## 6.3 Cable Routes

The electrical drawings shall detail the general route for cables, with the exact route to be defined on-site by the Contractor. For cables not defined on the layout drawings, it shall be the Contractor's responsibility to field route. The Contractor shall also 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 it shall be the Contractor's responsibility to coordinate the cable routes with other services. All cable routes shall be accepted by Urban Utilities' Representative prior to commencing the cable or cable pathway installation.

All 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 by the Contractor 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.

All 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.

It shall be the responsibility of the Contractor to ascertain that adequate space exists on the cable ladders and in conduits for the intended cable installation prior to commencing the cable, ladder or conduit installation.

All cables shall be installed in accordance with the method of installation (including spacings, bedding material and backfill) as defined in the Project Documentation. Cable sizes shall 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' Representative. Cables shall be installed neatly to ensure they can be readily traced and identified from origin to destination. Cables shall be installed so as to avoid crossovers with other cables. All installations shall be in accordance with the requirements of AS/NZS 3000 and AS/NZS 3008.1.1.

## 6.4 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' Representative 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 at all times during handling and installation operations. 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.

Any winch 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. Any cable jacks or lifting equipment shall be sized and rated for the weight and size of the cable drum.

At no time shall a cable be handled such that it 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' Representative. 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.

## 6.5 Cable Management and Cable Records

When cable is supplied in drum lengths allocated for specific circuits, it is the Contractor's responsibility to ensure the correct cable drums are used for the nominated circuits.

Unless otherwise agreed, the Contractor shall maintain a cable pulling schedule and cable drum schedule (or similar) 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 are to be recorded on the cable schedule as 'As- Built' information.

The Contractor shall be responsible for continuous monitoring and reporting of cables stored by the Contractor. Adequate levels of Contractor supplied cables shall always be maintained to ensure that the installation schedule is not delayed due to cable shortages. Similarly, Urban Utilities' Representative 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.

The Contractor shall provide "As-Built" drawings of cable routes including any deviations and their approval documentation. The Contractor shall also provide digital photos of underground cable installations where defined in the ITPs as part of the handover documentation.

## 6.6 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. All systems for clamping cables shall be accepted by Urban Utilities' Representative 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, and 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' Representative.

## 6.7 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.

## 6.8 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 the 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 (analog & digital)<br>Intrinsically Safe Fire & Gas |
| **2** | Medium | Non-Intrinsically Safe instrumentation (analog & digital)<br>Non-Intrinsically Safe Fire & Gas<br>ELV power & control (≤50V DC / ≤120V AC)<br>Telecommunication (Ethernet, Modbus, Fieldbus, telephony etc.) |
| **3A** | Low | LV power ≤20A<br>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.

## 6.9 Cable Spacing

Unless otherwise specified, the spacing between individual cables shall be as follows on cable ladders:

| Cable Type | Layers | Cable Spacing |
|---|---|---|
| Instrumentation<br>Communications<br>Control<br>LV Power (≤20A) | Multi-layered to 75% of ladder depth | Bunched |
| 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 |

All cable installation designs shall be supported by calculations.

## 6.10 Cable Bending Radii

In general, cable bending radii shall be as large as practical, and shall not be less than the supplier's recommended minimum bending radii. It shall be the responsibility of the Contractor to ensure the relevant cable data sheets are available so the bending radii can be taken into consideration when completing the 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.

## 6.11 Cable Jointing

Cables shall be installed in continuous, unbroken lengths without joints unless detailed otherwise in the Project Documentation or accepted by Urban Utilities' Representative. 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]<br>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]<br>Approved jointing kit installed in ladder[1] | Approved jointing kit inside a pit[1] |
| 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 Contractor shall have available for on-site reference, the Supplier's installation instructions for the jointing kits.

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 located 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.

All 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.

The location of all cable joints on above ground cable ladder shall be detailed on the cable layout design drawings to form part of the as-built information. On-site these locations shall be identified with suitable markers or signage.

## 6.12 Cable Terminations

### 6.12.1 General

The cores and screens of all cables shall be terminated in accordance with the recommendations of the supplier of cables, glands, switchgear and lugs.

All terminations shall be completed in a neat and tidy tradesman like manner as per best practice. All 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.

The Contractor shall be responsible for the correct phasing/connection of all cables.

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' Representative prior to commencement of works.

### 6.12.2 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:<br>• Tunnel terminals – bootlace type<br>• Stud terminals – ring type<br>• Other screw-in terminals – fork/spade type preferred | Copper conductors:<br>• Uninsulated tinned copper lugs, ring type<br><br>Aluminium conductors:<br>• 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 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 Contractor shall have available for on-site reference, the supplier's operating instructions for the crimping tools detailing the method for crimping the different types of lugs.
- 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
- All 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

### 6.12.3 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 except where specified otherwise in Project Documentation. | Cables shall be glanded as detailed in the standard installation drawings using the cable glands specified in the Project Documentation |
| LV cable screens (including VSD cables) | Earth at both ends | Purpose-designed, EMC reducing metallic glands required |

| Screen or Armour Type | Earthing Requirements | Glanding Requirements |
|---|---|---|
| Instrumentation, Communication & Control screens | Earth at PLC panel or MCC end only except where specified otherwise in Project Documentation. | Non-metallic glands permitted.<br><br>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 except where specified otherwise in Project Documentation | Purpose-designed armoured cable glands required<br><br>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.

### 6.12.4 Termination of HV Cables

The 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.

All HV cable termination kits shall be in accordance with the requirements of IEC 60502-4.

The Contractor shall have available for on-site reference, the supplier's installation instructions for the termination kits.

All HV cable terminations shall be completed by suitably qualified and experienced personnel.

Prior to commencing HV cable terminations the Contractor shall ensure that the system phase rotation on the switchboard is 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.

All cores shall have colour heat shrink on termination lugs or similar to identify the phase.

The Contractor shall be responsible for identification and procurement of all miscellaneous materials and consumables necessary for the termination of the cables 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' Representative for resolution.

## 6.12.5 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' Representative if required. The heat shrink on each lug shall be colour coded to identify the phase.

The Contractor shall be responsible for ensuring correct phasing, polarity and conductor identification throughout the installation.

For large power cables the cores 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.

All 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' Representative for resolution.

## 6.12.6 Termination of Control & Instrumentation Cables

Cores for each single cable shall be terminated in consecutive terminals and in logical order, where possible.

The Contractor shall terminate every spare core in every control and instrument cable at spare terminals in switchboards and LCS unless specifically indicated otherwise on termination drawings issued as part of the Contract.

All 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.

All 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.

### 6.12.7 Termination of Earthing Cables

All 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.

All 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.

## 6.13 Cable Glands

All 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 STP 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 STP is a special case with $H_2S$ corrosion observed throughout the plant. All cable glands at Luggage Point STP 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
    - 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 unless specified otherwise in the Project Documentation

- 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 TMS1203 *General Requirements for Installation of Electrical Equipment in Hazardous Areas* for cable glands required in hazardous area.

## 6.14 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 the 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.

## 6.15 Core Identification

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

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

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

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

- Power cable core identification will be by cable number, and core colour or number (core insulation)
- Ferrule labels shall be arranged to read from left to right and from bottom to top
- The same wire number shall be used on wires forming connections directly in series or parallel in the same panel
- Where cables for different items of equipment are terminated at the one location (e.g. field marshalling box) and wire numbers are the same for the different items, then each wire

number shall be prefixed with the item equipment number to distinguish between the cores. This shall be done whether or not it is shown on drawings.

## 6.16 Above-Ground Cables

### 6.16.1 General

All 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.

### 6.16.2 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 the 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' Representative, 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 the 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 |
| 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' Representative
    - Fabricated non-proprietary steel bends and tee fittings where indicated in the Project Documentation shall be supplied as part of the structural steelwork
- Cable ladders shall be fitted with a segregation barrier strip where defined in the 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 unless otherwise stated in the Project Documentation
    - 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' Representative 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' Representative
- 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
- Except where detailed in the Project Documentation, 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 the 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.

## 6.16.3 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.<br><br>Rigid metallic conduit, if connected to the equipotential bonding system<br><br>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<br><br>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.

All surface conduit runs shall be installed true, straight and squared with structural lines and shall follow the natural lines of the building or structure.

All conduits, unless accepted otherwise by the Urban Utilities' Representative, 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' Representative prior to installation. All flexible steel conduits shall have an outer PVC sheath.

All conduit runs shall be cleaned and swabbed to remove foreign matter and moisture prior to pulling in wire or cable.

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. Installation requirements are outlined in TMS1203 *General Requirements for Installation of Electrical Equipment in Hazardous Areas*.

Conduits, both flexible and rigid, installed outside shall be sealed or installed so as to prevent to accumulation of water and entry of water entry into junction boxes and equipment.

## 6.17 Underground Cables

### 6.17.1 General

All 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' Representative 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' Representative 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' Representative) 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.

## 6.17.2 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 | 300 | 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.

## 6.17.3 Underground Conduits

Unless otherwise specified in Project Documentation, the following requirements shall apply regarding conduit:

- All 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

Unless otherwise specified in Project Documentation, 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.

Unless otherwise specified in Project Documentation, 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

Unless otherwise specified in Project Documentation, 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' Representative 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 kerbline or shoulder where applicable except where shown on the drawings.

Unless otherwise specified in Project Documentation, 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
- All 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 at a later date for future cable installation
- The positioning of the stub up shall be verified as correct before pouring of concrete

Unless otherwise specified in Project Documentation, 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

Unless otherwise specified in Project Documentation, 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 the 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' Representative before use
- All conduits shall be installed at a depth not less than 600mm below the finished ground surface level (Unless under concrete - refer 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' Representative:
    - 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

Unless otherwise specified in Project Documentation, 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.
- The 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

### 6.17.4 Cable Pits

In all instances cable pits and covers shall be traffic rated to suit the application. The traffic rating shall be defined in the Project Documentation or as directed by Urban Utilities' Representative. 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<br>Occasional traffic<br>Transient light vehicle loads or large equipment on trolleys | Vehicle accessible footpaths or plant areas<br>Driveways | B |
| Low speed<br>Intermittent traffic<br>Persistent light vehicle loads | Residential & minor roads | C |
| High Speed<br>Consistent traffic<br>Transient heavy vehicle loads | Major roads<br>Highway shoulders (not for highway crossings)<br>Warehouses, laydown yards & loading docks<br>Treatment plant roads, water and sewage pump station roads and facility carparks | D |

Unless detailed otherwise in Project Documentation, 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' Representative 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.
- 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' Representative) 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

Unless detailed otherwise in project documentation, 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

Unless detailed otherwise in project documentation, 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)

### 6.17.5 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, the Contactor shall use water blasting at maximum 2000kPa pressure to locate underground services.

The 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.

All excavation and backfilling activities shall adhere to the requirements detailed in the CEMP, 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.

All 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. The Contractor shall be responsible for ascertaining the finished ground level for the areas to be excavated.

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 unless detailed otherwise in the project documentation:

| 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 |

All trenches to be excavated to a depth greater than 1300mm shall be accepted by Urban Utilities' Representative prior to commencing works.

Any paving, drainage, road surface or similar disturbed by trenching shall be reinstated to the original condition.

All backfilling and compaction (including compaction levels) of trenches including the re-instatement of the finished surface shall be in accordance with the requirements of the Project Documentation.

Trenches must 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.

All surplus material and spoil remaining after completion of the backfilling shall be removed and disposed of as directed by Urban Utilities' Representative and in accordance with the CEMP or stockpiled for future site rehabilitation as directed by Urban Utilities' Representative.

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 from work under the Contracts. Any damage caused to paving and other structures due to excavation activities shall be repaired by the Contractor.

Pavement surfaces, including turf, concrete or brick paved areas and pathways, shall be reinstated by the Contractor.

## 6.17.6 Cable Route Markers

The route 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 the 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.

## 6.17.7 Underground Cable Ducts

All 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.

The 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.

The cable duct design shall incorporate cable penetrations that can be adequately sealed upon completion of the installation.

## 6.17.8 Cast In-Situ Conduit

Unless specified otherwise, all conduit to be cast into concrete shall be heavy duty rigid PVC in accordance with AS/NZS 2053.

All 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.

All 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.

All conduits, unless accepted otherwise by the Urban Utilities' Representative, 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 at a later date for future cable installation.

Generally conduits shall stub up either directly below or adjacent to the equipment to be connected. The Contractor shall be responsible to ensure that the positioning of the stub up is 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. Installation requirements are outlined in TMS1203 *General Requirements for Installation of Electrical Equipment in Hazardous Areas*.

## 6.17.9 Horizontal Directional Drilling

For all 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. All engineering design shall be accepted by Urban Utilities' Representative 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 the preliminary Urban Utilities design. These shall be calculated and submitted for approval
- The 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 submitted to Urban Utilities for approval. Compliance with Government regulations and permits shall be confirmed
- Urban Utilities will carry out a detailed geotechnical survey. This information will be included in Project Documentation

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 CEMP in line with the Land Release Management Plan requirements.

Spoil or waste material generated shall be disposed of in accordance with the CEMP.

## 6.18 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 the 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 the Project Documentation or as agreed with the Urban Utilities representative.

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 the Project Documentation.

All existing single insulated wiring, if disturbed by the Project, (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 Representative.

# 7 ETHERNET AND FIBRE OPTIC CABLING

## 7.1 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 by the Contractor 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 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 |
| 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 |

## 7.2 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 TMS1202 *Control System Implementation*. 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

### 7.2.1 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 unless specified otherwise in the project documentation
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 grade stainless steel tracer wire to enable detection of the fibre optic cable route along the entire length

### 7.2.2 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.

### 7.2.3 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

# 8 PROTECTIVE EARTHING AND LIGHTNING PROTECTION

## 8.1 Earthing System Overview

All earthing works shall be compliant with AS/NZS 3000 and the associated purpose specific directives detailed in the 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 as detailed in the Project Documentation. 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 unless specified otherwise in the project documentation.

An equipotential earthing loop shall be installed throughout the plant area unless otherwise detailed in the Project Documentation. 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 as detailed in the Project Documentation (typically via an MEN link located in the main LV distribution switchboard) or where not detailed shall be earthed to the transformer earth bar.

All 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. All exposed conductive parts of equipment, piping, vessels and structural items in hazardous areas shall be effectively bonded so as to prevent the accumulation of static charge and for lightning protection.

## 8.2 Equipotential Earthing

The buried earth grids shall utilise radial taps for bonding to the following where detailed in the Project Documentation:

- significant equipment (motors, tanks, vessels, etc)
- structural steelwork
- reinforcing steelwork in the concrete footings
- field earth bars
- fences and gates

The project installation drawings may detail the specific arrangement of these bonds.

The equipotential earth loop cable that runs throughout the plant on the cable ladder system shall utilise radial taps for bonding to the following where detailed in the Project Documentation:

- significant equipment (motors, tanks, vessels, etc)
- structural steelwork
- cable ladder
- field earth bars

The 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.

Where detailed in Project Documentation, 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' Representative.

## 8.3 Buried Earth Grids and Grading Rings

Unless otherwise stated in the Project documentation 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.

All buried earth grid connections shall be exothermically welded (Cadweld) or made by Urban Utilities accepted “C” compression connectors. Refer Section 8.7.

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.

It shall be the responsibility of the contractor to determine the finished ground level prior to the commencement of the installation of buried earthing grids.

It shall be the responsibility of the contractor to schedule and coordinate the works to 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.

Any 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. All earth grid repairs shall be tested to satisfaction of Urban Utilities' Representative to verify the integrity of the repaired buried grid.

## 8.4 Earth Electrodes

The earthing installation drawings for the project may detail the equipment and installation arrangement for 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.

All 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 the Project Documentation.

The Contractor shall nominate a suitable electrode numbering convention for Urban Utilities acceptance where electrode tag numbers have not been assigned in the 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.

## 8.5 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 if not otherwise detailed in the Project Documentation. 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 to the Project Documentations 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.

## 8.6 Earth Cables

Unless otherwise specified in the Project documentation the 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 unless specified otherwise in the Project Documentation. Green/yellow PVC tape shall not be used in lieu of conductor insulation.

## 8.7 Earth Connections

All above ground exposed cable taps, splices and connections shall be made via compression crimps unless otherwise specified in the Project Documentation. All crimps shall be sized to suit the cables and shall utilise the correct tool, dies and procedure as instructed by the crimp supplier. All crimp connections shall be primed and wrapped (Denso products or equivalent) to maintain the integrity of the connection. All 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. All earth bar connections shall be coated with a primer (Denso product or equivalent) to protect against corrosion.

Unless otherwise detailed in the Project Documentation, all above ground joints and connections shall be visible and accessible.

Earth cables shall be uniquely identified as per section 6.14 to match the project documentation. The contractor shall assign earth cable tag numbers where not specifically identified. Project 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, unless otherwise specified in the Project Documentation.

### 8.7.1 Buried Earth Connections Using Exothermic Welding

All 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).

All cad-welding and pre-welding treatment of the conductors shall be in accordance with the instructions of the supplier of the cad welding equipment. All buried connections shall be inspected to confirm the integrity of the connection prior to burial.

### 8.7.2 Buried Earth Connections Using Compression Connectors

The Contractor shall submit to Urban Utilities for acceptance details of the compression connection system proposed for each combination of conductor types and sizes to be joined, including:

- connector type (brand and part number)
- compression die type (brand and part number)
- compression tool type (brand and part number)

The 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.

The “C” shaped compression fitting is the preferred compression type connector.

Compression connections shall be irreversible.

The preferred type of compression connector is Burndy Hyground. Equivalent connectors from Cabac and Panduit are also accepted.

The combination of compression connector, compression tool and die shall be compatible and suitable for the conductor sizes being joined.

The compression tool shall be of a positive locking action that shall not release until the compression joint is completed.

The compression die 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.

All compression connections shall be primed and wrapped (Denso products or equivalent) to maintain the integrity of the connection. All compression connections shall be inspected to confirm the integrity of the connection prior to wrapping.

## 8.8 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 the Project Documentation or 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.

## 8.9 Cable Ladder

All 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.

## 8.10 Lightning Protection

Lightning protection as shown on the Project Documentation 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 8.2 shall apply, and in addition, the Contractor shall take particular measures 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 by the Contractor at his own cost.

Refer TMS1203 *General Requirements for Installation of Electrical Equipment in Hazardous Areas* for lightning protection of areas with a Hazardous Areas classification.

# 9 LIGHTING AND SMALL POWER

## 9.1 General

The Light and Small Power Layout Drawings, Distribution Board Drawings and other Project Documentation shall detail the lighting and small power requirements.

## 9.2 Distribution Boards

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

The 230V lighting and small power electrical loads shall be balanced across all three (3) phases.

Any additional lighting and small power loads not defined in the 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' Representative prior to commencing the installation works.

## 9.3 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. The 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.

The hinged poles may be clamped to the walkway handrails using proprietary clamps unless otherwise specified in the Project Documentation. 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' Representative 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 the Project Documentation. The lighting circuit identification may be achieved by cable labels if accepted by Urban Utilities' Representative.

All 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.

## 9.4 Street and Area Flood Lighting

The 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. The 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. The pole shall also be bonded to the earth in the lighting supply cable via an appropriately rated Contractor supplied 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. Where specified in the Project Documentation 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.

All light poles shall be clearly labelled defining the supply circuit and light fitting tag number (where applicable) in accordance with the Project Documentation. The 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.

All luminaires and control gear shall be installed in accordance with the supplier's recommendations.

## 9.5 Luminaires

Luminaires shall be LED unless specified otherwise in the Project Documentation.

Lamps and tubes of the specified type, size and manufacture shall be installed in the lighting fittings.

All 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 TMS1203 *General Requirements for Installation of Electrical Equipment in Hazardous Areas*.

## 9.6 Power Outlets and Switches

Unless detailed otherwise in the Project Documentation, power outlets and switches to be installed in the plant outdoor areas shall be as follows:

- heavy duty industrial grade
- UV and corrosion resistant
- minimum IP65 ingress protection rated
- have an auto closing flap on the socket outlet
- for single phase outlets be 230V 15A
- for three phase outlet applications be 5 pin

The power/current ratings for each power outlet shall be as detailed in the Project Documentation. The power rating for light switches shall be matched to the circuit breaker rating for the supply circuit.

The standard installation drawings shall detail the typical installation arrangements for power outlets and switches in the plant. Each outlet and switch shall be labelled to indicate from which distribution board and circuit breaker it is fed and the outlet tag number. The outlet tag number shall be correlated with the associated circuit breaker number on the distribution board legend.

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.

Unless detailed otherwise in the Project Documentation, all power outlets (single and three phase) shall be provided with earth leakage protection incorporated into the circuit breakers within the distribution boards.

Unless detailed otherwise in the Project Documentation, for non-industrial areas (i.e. offices, control rooms, etc), 10A, moulded plastic, flush mounting, general purpose outlets shall be installed.

These outlets shall be clearly and permanently labelled and coloured as follows:

- White - Non-essential supply
- Red - Essential or UPS supply

Red UPS outlets shall be labelled “Not for General Use”.

## 9.7 Welding Outlets

Welding outlets shall be in accordance with the requirements for three phase outlets installed in outdoor plant areas as detailed in section 9.6.

Unless detailed otherwise in the Project Documentation, welding outlets shall be 400 V 63A, 3P+N and E.

## 9.8 Decontactors

Decontactors shall be installed on equipment as defined in the 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 unless shown otherwise in the Project Documentation.

# 10 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 the Project Documentation and the relevant codes, standards and regulations.

## 10.1 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.

All danger and warning signs shall be in accordance with AS1319 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
- Sign posts 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 on switchboard compartments indicating maximum voltage level in the compartment
- Signs on switchboards indicating where all voltage sources are fed from
- All 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
- Signs indicating emergency routes to the nearest hospital and emergency phone numbers shall be displayed in a visible location for all high voltage switchrooms and installations (as required by section 10 of AS2067)
- Any signs not specified in the Project Documentation which may be required in order to comply with the relevant regulations, codes and standards

## 10.2 Equipment Labels

Electrical equipment shall be labelled by means of permanently attached tag labels in accordance with the 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.

The Contractor shall submit a typical label for each type of equipment to Urban Utilities' Representative 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 Ex hazardous areas 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.

# 11 QUALITY ASSURANCE, INSPECTION AND TESTING

The Contractor shall demonstrate that all works comply fully with the specification and all associated Project Documentation.

## 11.1 Quality Assurance

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

The Contractor shall submit a quality control program for Urban Utilities' Representative review at the time of Tender. The Contractor shall cooperate with Urban Utilities' Representative and Urban Utilities' nominated auditors during all stages of the works with respect to quality assurance matters.

Components and works shall be inspected and tested in accordance with quality control and assurance procedures nominated by the Contractor and accepted by Urban Utilities' Representative. The Contractor shall identify hold points for access by Urban Utilities' Representative.

## 11.2 Inspection and Testing

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

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

### 11.2.1 Inspection and Test Plan (ITP)

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

Prior to commencement of the relevant works the ITPs shall be customised by the Contractor for the project works and have been reviewed and accepted by Urban Utilities' Representative. Urban Utilities' Representative and the Contractor shall sign off the final version of the ITPs, which, thereafter, shall form part of the contractual documents. The ITPs shall encompass the testing requirements of all relevant standards and statutory/regulatory requirements.

The Contractor shall be responsible for the planning and execution of all inspections and tests, with Urban Utilities' Representative having the right to witness any or all of the inspections or tests.

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

The Contractor shall notify Urban Utilities' Representative, at least 4 days in advance, of the date on which any of the inspections or tests nominated as Hold or Witness points on the ITPs are due to be carried out.

ITPs and Checksheets shall be completed for all works to prove it has been satisfactorily tested to meet all defined requirements whether or not witnessed by Urban Utilities' Representative.

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

The following typical documents outline the minimum content to be completed by the Contractor 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

## 11.3 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 that will detail the exact inspection requirements.

## 11.4 Control System Testing

Refer to TMS1202 Control System Implementation Standard Technical Specification for quality assurance, testing and commissioning requirements for all control system equipment, including PLCs, HMIs, SCADA and network devices.

## 11.5 Cable Testing - Low voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for all cables. However as a 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

## 11.6 Cable Testing – High Voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for all HV cables. However as a 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 the Contractor shall confirm acceptance of the proposed cable testing procedures 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.

## 11.7 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.

## 11.8 Earth System Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for all earthing systems. However as a 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

## 11.9 Power Transformer Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for transformers. However as a 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

## 11.10 Switchboard Testing – Low Voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for each switchboard. However as a 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 micro-ohm resistance test across incomer cable termination, across incomer switch in closed position, and from incomer to outgoing terminals of every power circuit over 150 A
- Check phasing of all incoming and outgoing circuits
- Operate each device (switch, circuit breaker, 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 the Project Documentation
- Confirm function of all local and remote switching operations

## 11.11 Switchboard Testing – High voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for HV Switchboards. However as a minimum the same tests apply as per Section 11.10 for LV Switchboards and the 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
- Confirm function of all local and remote switching operations for circuit breakers and isolators

## 11.12 HV Circuit Breaker Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for HV Circuit Breakers. However as a 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

## 11.13 Instrument Transformer Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for instrument transformers. However as a 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

## 11.14 Protection Relay Testing

The relevant Inspection and Test Plans shall detail the exact test requirements for Protection Relays. However as a 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

## 11.15 Motor testing – Low Voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for all motors. However as a 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

## 11.16 Motor testing – High Voltage

The relevant Inspection and Test Plans shall detail the exact test requirements for HV motors. However as a minimum the same tests apply as per Section 11.15 LV Motor Testing and the additional testing as follows:

- 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

## 11.17 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. However as a 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

## 11.18 Site Acceptance Testing (SAT)

The Contractor shall develop a Site Acceptance Test (SAT) document (test plan/strategy and full complement of test sheets) that clearly defines the logical sequence and structured testing of the complete installation (switchboard and all field devices) in accordance with the issued drawings/documentation and standard templates. This includes preparation of a switchboard changeover commissioning plan for each site installation works. SAT documentation will be site specific and will require Urban Utilities review and approval prior to commencement of each SAT.

The Contractor shall complete testing, pre-commissioning and commissioning of the installation works to the satisfaction of the Urban Utilities Representative 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 by the Contractor on the day of every Site Acceptance Test. The Contractor shall review this checklist prior to Site Acceptance Testing to ensure all testing can be completed on the day of Site Acceptance Testing.

## 11.19 Site Functional Testing

The Contractor shall provide full Site Functional Testing in the presence of Urban Utilities Representatives. 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)
- Correct function of telemetry and SCADA remote indication at the Urban Utilities Telemetry Systems Control Room for all digital and analogue signals

## 11.20 Settings and Pre-commissioning

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

## 11.21 Failure

Any works or equipment that fails an inspection or test shall be repaired or replaced. All inspections and tests which are affected by the rework shall be repeated.

# 12 TRAINING AND DOCUMENTATION

The Contractor shall be responsible for providing all documentation in accordance with the Project Documentation requirements and the Deliverables Requirements List (DRL) included in the Project Documentation.

As a minimum the following documentation shall be progressively maintained by the Contractor during the execution of the works:

- Quality Assurance records including ITPs and the associated check-sheets and test records for all elements of the works
- 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' Representative accepted changes to the Project Documentation
- A record of all Urban Utilities' Representative supplied directives or Site Instructions
- A record of all submitted Requests for Information and the associated Urban Utilities' Representative responses
- A record of all Urban Utilities' Representative accepted Contractor 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 the contract works the above listed documentation shall be officially submitted by the Contractor to Urban Utilities' Representative as well as a complete set of the final signed-off As-Built documentation.

## 12.1 Training

The Contractor shall provide a comprehensive training course for all electrical equipment, motors, switchboards and protection systems included in the Contract scope of work unless specified otherwise in the Project Documentation.

The training includes 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 which shall be supplemented by the switchboard and electrical installation operations and maintenance manual
- 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 walk-through and inspection, showing all the electrical and protection related equipment, the installation locations, methods of connection and practical live demonstration
- Engineers and technical staff 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.

## 12.2 Site Documentation

### 12.2.1 Site Record Drawings

During the site works the Contractor shall maintain an updated set of site record drawings and make them available for inspection by 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 the site works, the red-lined amended drawings are referred to as the “site red-line record drawings”, and shall be stamped, signed by the Contractor’s site representative and dated as well as signed as approved by the nominated Electrical RPEQ and submitted to Urban Utilities.

### 12.2.2 Miscellaneous Documentation

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

- Quality Assurance records including 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 the Project Documentation
- A record of all Urban Utilities supplied directives or Site Instructions
- A record of all Contractor 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 by the Contractor to Urban Utilities.

## 12.3 As Built Documentation

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

It is the responsibility of the Contractor to:

- Update the master set of drawings as required
- Store and maintain up to date inspection checksheets, test result records and certificates generated during testing of the installation works

Test result records, certificates and drawings with the red-line mark-ups shall be kept 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.

## 12.3.1 As Built Drawings

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

- 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

The Contractor shall mark As Built corrections on construction drawings used for installation. "As-Built", shall be clearly and legibly marked up on all drawings. 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 by the Contractor. 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.

## 12.3.2 As Built Documents

Electrical Documents as listed in CHE 486 Deliverables Requirements (DRL) shall be as As-Built.

An RPEQ shall certify As Built documents.

All as-built documents shall be collated into a Dossier to be handed over prior to Practical Completion

## 12.4 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 by the Contractor:

- 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.

## 12.5 Software Configuration Files

At completion of the commissioning phase the following software configuration files and code shall be uploaded to an Urban Utilities Sharefile link:

- PLC/RTU Code and Configuration Files
- SCADA Projects, Configuration and Driver Files
- Local HMI Terminals Configuration Files
- Network Equipment Configuration Files (routers, network switches, modems etc)
- Protocol gateway converters Configuration Files
- 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

## 12.6 Operations and Maintenance Manuals

The contractor shall provide Operations and Maintenance (O&M) Manuals 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.

The Contractor shall provide the O&M manuals in compliance with SEQ Water Supply and Sewerage Design & Construction Code (SEQ WS&S D&C Code) 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 and year of installation
- Contractor's 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 the Contractor shall collate and submit the final O&M manual alongside the final Testing and Commissioning Dossier. Timings for draft and final deliverables shall be as per the Contract.

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 12.3, 12.4 and 12.5 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

### 12.6.1 Generic Manuals

Vendor generic manuals shall be provided with a searchable data sheet attached by the Contractor to indicate the actual equipment supplied.

## 12.7 Configuration Files

All configurable electronic devices supplied in the installation shall be provided by the Contractor with the as commissioned software configuration files. Programming software licences and hardware accessories required to fault find and reconfigure the devices shall also be provided by the Contractor.