

Specification
For
**Electrical
Installations at
Network Sites**

Pr9380



Unitywater

Pr9380 - Specification for Electrical Installations at Network Sites

Document Control

This document is only valid on the day it was printed.

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Version Review

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11	JD	BVW	24/02/2020 (R5)	Add new section 3.6 Power Systems Analysis Requirements
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Nil.

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1. Purpose

- 1.0.1 The purpose of this Specification is to define Unitywater requirements for manufactured electrical equipment and electrical installation works at all sites within the Unitywater network excluding major treatment plants. This includes but is not limited to water and sewage pumps stations, flowmeter and reservoir sites.
- 1.0.2 The Specification defines quality, performance, reliability, durability, safety and appearance requirements for these installations.

2. Scope

- 2.0.1 The scope of this Specification applies for complete and partial electrical installation works at Unitywater network sites. This includes but is not limited to the following:
- Electrical design and documentation, preparation of workshop drawings, as constructed drawings, inspection and test plans, operation and maintenance manuals, etc.;
 - Design, manufacture, supply, installation and testing of all electrical switchboards and local control stations;
 - Supply, installation, testing and commissioning of all electrical cabling and cable supports;
 - Supply, installation, testing and commissioning of all electrical equipment.
- 2.0.2 This Specification shall be used in conjunction with the associated specifications or requirements as detailed in the project specific documentation.
- 2.0.3 This Specification shall apply to works being constructed directly for Unitywater or other authority or for a Contractor who will hand over the ownership of the constructed works to Unitywater or private owners who will retain ownership but will require Unitywater to operate or monitor the asset.
- 2.0.4 Where the works are performed without a nominated Contract Superintendent, the necessary approvals shall be sought from Unitywater's Electrical, Instrumentation and Control (EIC) Manager. Under these circumstances, any reference to the Contract Superintendent in this Specification shall refer to the EIC Manager.

3. References

3.1. General

- 3.1.1 All equipment and workmanship shall conform to the most recent requirements of relevant statutory Local, State and Commonwealth requirements and applicable, current Australian Standards.
- 3.1.2 Reference to specific clauses of the various codes is intended to highlight those points and shall not be taken to imply a lesser importance for all other applicable clauses.
- 3.1.3 All the works shall conform to the Rules and Regulations of the Statutory Authorities having jurisdiction over the Site.

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- 3.1.4 If the requirements of this Specification do not articulate the minimum requirements of the statutory regulations and standards, the regulatory requirements are taken to apply. If the requirements of this Specification are more exacting than the minimum requirements of the statutory regulations and standards, the former shall apply.
- 3.1.5 All Materials, fittings, accessories and equipment supplied by the Contractor shall be new and the best obtainable of their kind and shall comply in all respects with the requirements of the relevant Standards Australia specifications.

3.2. Applicable Legislation and Regulation

- 3.4.1 The following primary legislation and regulations apply in relation to this Specification:
- *Electricity Act 1994* (Qld);
 - *Electricity Regulations 2006* (Qld);
 - *Electrical Safety Act 2002* (Qld);
 - *Electrical Safety Regulation 2013* (Qld);
 - *Work Health and Safety Act 2011* (Qld);
 - *Work Health and Safety Regulations 2011* (Qld);
 - *Telecommunications Interception Act 2009* (Qld);
 - *Telecommunications Act 1997* (Cth).

3.3. Codes of Practice (ratified by Legislation)

- 3.3.1 The following Codes of Practice ratified by Queensland legislation apply in relation to this Specification:
- South East Queensland Water and Sewerage Design and Construction Code (SEQ WS & S D & C Code);
 - Building Code of Australia (BCA).

3.4. Codes of Practice (not ratified by Legislation)

- 3.4.1 The following Codes of Practice not ratified by Queensland legislation apply in relation to this Specification:
- Energex Supply and Planning Manual (BMS 01697, Energex 2013);
 - Energex Planning Guidelines “Harmonic Guidelines – Variable Speed Drives”;
 - Unitywater Mechanical Installation Specification;
 - Unitywater Civil Works Specification;
 - Unitywater Accepted Electrical Equipment List ([F10678](#)).

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3.5. International and Australian Standards

Standard	Title
AS/NZS3000	Electrical installations (known as the Australian/New Zealand Wiring Rules) (2007)
AS3008	Electrical installations – section of cables, cables for alternating voltages up to 0.6/1kV- typical Australian installation conditions (2009/amdt 2011)
AS/NZS3439.1	Low-voltage switchgear and controlgear assemblies – Particular requirements for busbar trunking systems (busways)
AS2700	Colour standards for general purposes (2011)
AS/NZS 5000.1	Electric cables - Polymeric insulated - For working voltages up to and including 0.6/1 (1.2) kV (2005/amdt 2006)
AS/NZS1660.1	Test methods for electric cables, cords and conductors – conductors and metallic components (1998)
AS/NZS 1660.2.1	Test methods for electric cables, cords and conductors – Insulation, extruded semi-conductive screens and non-metallic sheaths – methods for general application (1998/amdt 2001)
AS/NZS3111	Approval and test specification – Miniature overcurrent circuit-breakers (2009/amdt 2011)
AS/NZS3947.3	Low-voltage switchgear and controlgear – Switches, disconnectors, switch-disconnectors and fuse-combination units (2001)
AS60947.1	Low-voltage switchgear and controlgear – general rules (2004)
AS2768	ISO 2768 General tolerances – Part 1 – Tolerances for linear and angular dimensions without individual tolerance indications
AS1359.0	Rotating electrical machines – General requirements – Introduction and list of parts (1998)
AS60044.1	Instrument Transformers – Current transformers

3.6. Power Systems Analysis Requirements

3.6.1 All electrical designs shall comply with [Pr10618](#) - Specification for Power Systems Analysis and Arc Flash Studies.

4. Definitions/Abbreviations

Term	Meaning
Contract	The agreement between Unitywater and the Contractor
Contractor	The person or company bound to execute the work under the Contract

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Term	Meaning
Superintendent	The person nominated by Unitywater in the Annexure to the Contract
Works	The whole of the work to be executed in accordance with the Contract, including variations provided for by the Contract which is to be handed over to Unitywater
AC or ac	Alternating current
CB	Circuit Breaker
DC or dc	Direct current
LCS	Local Control Station
LV	Low Voltage
PLC	Programmable Logic Controller
SCADA	Supervisory Control and Data Acquisition
HMI	Human Machine Interface

5. Preconstruction

5.1. Design Requirements

- 5.1.1 The Contractor shall prepare drawings as required in the specification and shall be responsible for the complete design of the Switchboard/Telemetry Panel/Disconnection Cubicle, including supporting frames and all other details necessary to obtain proper performance of the switchboards to this specification and all relevant Australian Standards.
- 5.1.2 All equipment shall be located and installed so that it will be readily accessible for operation and maintenance. Unitywater reserves the right to require minor changes in location of equipment prior to roughing in without incurring any additional costs or charges.
- 5.1.3 A switchboard design is to accord with Unitywater's standard electrical drawings; any deviations shall be approved in writing by the Contract Superintendent or the nominated representative.
- 5.1.4 All equipment shall comply with Unitywater's [F10678](#) – Accepted Electrical Equipment List unless otherwise specified in project specifications or approved in writing by the Contract Superintendent or their nominated representative.
- 5.1.5 The Contractor shall submit the following calculations to the Superintendent prior to the commencement of installation works:
- Voltage drop for all power cables including mains and sub mains;
 - Earth fault loop impedance for all power cables including mains and sub mains;
 - Cable sizing for all power cables including mains and sub mains;
 - Switchboard fault current level.

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5.1.6 The design life for all electrical components shall be 20 years.

5.2. Site Conditions

5.2.1 The Contractor shall familiarise themselves with site conditions, including existing services and any requirements for access to plant and equipment.

6. Electrical Supply

6.1.1 The electrical supply to the switchboard shall be a 3-phase 415V AC 50 Hz M.E.N. system.

6.1.2 The Contractor shall submit all applicable forms to the Supply Authority and Unitywater's Procurement Team (procurement@unitywater.com).

6.1.3 The Contractor shall supply and install new consumer mains and supply authority metering for each installation.

6.1.4 The consumer mains cabling shall be suitably sized for connection of the electrical load with an additional 10% minimum spare capacity and the voltage drop requirements such that the voltage drop of the entire installation shall be in accordance with AS/NZS 3000 and AS 3008.

6.1.5 Please refer to Section 9.4 for further details on the mains and sub-mains cabling requirements.

7. Control Systems

7.1.1 Third party control systems shall generally not be accepted by Unitywater and the contractor shall utilise wherever possible the control systems contained within this specification and the UW standard drawings.

7.1.2 All integration/programming shall be undertaken only by Unitywater staff or Unitywater approved integrators.

7.1.3 The contractor shall wherever reasonable engineer control systems using the currently accepted Unitywater control platform in terms of SCADA, RTUs, PLCs, HMIs and Radios and utilise under the guidance of UW standard UW code, function blocks, protocols, templates, genies, libraries and general programming practices in terms of quality control.

7.1.4 Where the current Unitywater control platform is not suitable for the systems supplied, written approval shall be sought from the EIC manager to deviate from the current control system standards.

7.1.5 Where third party controllers are approved by Unitywater for a project, all programming cables and software licences shall be supplied to Unitywater and training given regarding programming and replacement. All critical systems shall be supplied with a backup controller/PLC pre-programmed and ready for installation.

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8. Switchboard Design and Construction

8.1. General Requirements

- 8.1.1 Switchboard layout, arrangement of electrical components and wiring shall generally be in accordance with the relevant Unitywater standard electrical drawings.
- 8.1.2 Switchboards shall have a minimum enclosure rating of IP56, with exception of the vents, for externally mounted switchboards and minimum enclosure rating of IP52 for switchboards housed within a building.
- 8.1.3 Switchboards shall be designed and installed with a minimum of 20 % spare capacity in each compartment including cable ducts, gland plates and equipment mounting pans.

8.2. Fault Capacity

- 8.2.1 The switchboard shall comply with the requirements of the current edition of AS/NZS3000 with particular attention to Clause 2.4 - Fault Protection and Clause 2.5 - Protection Against Overcurrent.
- 8.2.2 If the fault level is 10 kA or greater, the switchboard/s supplied shall not be a standard Unitywater switchboard. A switchboard of the arc fault containment type in accordance with Clauses 3.2.3 and 3.2.4 of the Standard shall be supplied. Acceptable protection for operators shall be provided in the event of an internal arcing fault occurring on the line side of a protective device in any switchboard compartment.
- 8.2.3 A recognized testing authority in accordance with the standard test procedures detailed in AS/NZS 3439.1 shall have tested the design being offered. Acceptable protection shall be as defined in the Annex to AS/NZS 3439.1.
- 8.2.4 The construction methods and protective devices or approved equivalent used in the tested switchboard shall be the same as in the switchboard supplied.

8.3. Switchboard construction

- 8.3.1 The switchboard shall be a totally enclosed self-supporting metal structure housing all electrical equipment necessary for the complete operation of the pumping station. The equipment shall be grouped in accordance with Unitywater's standard electrical drawings. If not shown on the standard drawings the equipment shall be grouped according to the voltage level and function.
- 8.3.2 The complete switchboard shall be prefabricated from minimum of 3 mm marine grade aluminium with adequate supports to withstand the mechanical stresses which may occur during operation, fault conditions, transport and erection. All edges and corners are to be accurately and neatly folded.
- 8.3.3 Indoor switchboards may use alternative materials with approval from the superintendent.
- 8.3.4 All metalwork is to be welded at joints. All external joints are to be fully (continuous) welded and stiffened where necessary to form a ridged weatherproof enclosure. All welds are to be ground smooth and free from crevices. All burrs and sharp edges are to be removed prior to powder coating.

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- 8.3.5 The switchboard cabinet and exterior doors shall be powder coated mist green (AS 2700 colour G54). A UV stable clear anti-graffiti powder coating shall be applied to all exposed panels for outdoor switchboards.
- 8.3.6 The escutcheons and equipment panels shall be powder coated white (AS 2700 colour N14).
- 8.3.7 All internal joints in the cable entry compartment shall be fully continuous welded to form a sealed enclosure.
- 8.3.8 The switchboard shall be fitted with sufficient vents and vent fans to meet the cooling requirements of equipment selected. The switchboard vent cowls are to be fully welded to the walls of the switchboard and the bottom edge of each cowl is to cover the bottom of the vent cut-out by a minimum of 30 mm. Each vent is to be fitted with removable stainless steel gauze with 1.5 mm² openings. The gauze shall be retained by metal framing welded to the inside of the cubicle. The inside of the ventilation openings shall be fitted with removable dust filters which can be readily cleaned or replaced.
- 8.3.9 Sun shields shall be fitted to the front, back and sides of all outdoor switchboards as indicated on Unitywater's standard switchboard drawings. The sun shields are to be bolted to studs welded to the main panel using stainless steel button head socket bolts. Sun shields are not required for indoor switchboards.
- 8.3.10 Sunhoods shall be fitted to all outdoor switchboards as detailed on Unitywater's standard switchboard drawings. The sunhood shall extend 600mm from the front edge of the switchboard to provide protection from the sun and rain. Sunhoods are not required for indoor switchboards.
- 8.3.11 The switchboard shall be fitted with a minimum of two (2) pairs of lifting eye bolts as per Unitywater's standard switchboard drawings. The eye bolts shall not penetrate through the switchboard cubicle and shall be removable.
- 8.3.12 Any door shrouding shall be fitted with a removable clear PVC cover and shall be installed so that it slides between two rails and is fixed by minimum of hardware.
- 8.3.13 All doors shall be fitted with stainless steel door stays to hold the doors open at a minimum 105 degrees for exterior doors and 90 degrees for interior doors.
- 8.3.14 Doors shall include a neoprene gasket to exclude water and dust. Gaskets shall be fixed to the doors without stressing and retained by means of metal framing. Gaskets shall be protected from direct sunlight.
- 8.3.15 Hinges shall be lift-off type chrome plated solid brass body (80 mm minimum length) with stainless steel hinge pins.
- 8.3.16 Exterior doors shall have 3-point locking system (locking bars to be fitted with rollers) and chrome plated profile locking swing handles capable of exerting sufficient pressure to ensure proper contact of the sealing medium all around the door. Handles shall be flush mounted with the doors.
- 8.3.17 Locks in handles on the exterior doors shall use a spring loaded quarter turn lock, keyed to the Unitywater key structure as per the standard switchboard drawings. The Contractor shall confirm keying arrangements for non-standard switchboards.
- 8.3.18 All DIN rail shall be aluminium.

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- 8.3.19 Unless shown otherwise, all fixing hardware used in the construction of the switchboard and the mounting support of equipment is to be minimum 316 grade stainless steel. Anti-galling compound shall be used.
- 8.3.20 All bolts, metal threads and screws are to be used with hexagon machined nuts or tapped holes having a minimum thickness equal to or greater than three times the thread pitch. Self-drilling / tapping screws and the like are not to be used under any circumstances.
- 8.3.21 All internal escutcheon doors are to be fitted with chrome plated quarter turn locks with 8 mm solid square insert. The Contractor shall supply two (2) suitable key tools with each switchboard.
- 8.3.22 The switchboard shall be effectively sealed to prevent the ingress of gases from the well. This shall be achieved by ensuring the base plate of the section above the cable entry compartment is fully welded and all access plates sealed using a 25 mm x 6 mm neoprene rubber gasket.
- 8.3.23 Legend card holders shall be fitted to the inside of the door to each compartment housing circuit breakers.
- 8.3.24 Drawing/document holders to suit A3 binder and/or equipment manuals, 460 mm(W) x 280 mm(H) x 25 mm(D), shall be fitted to the inside of the exterior door housing the pump starter compartments.
- 8.3.25 All doors, hinged panels and removable panels shall have flexible earth straps to the switchboard frame.
- 8.3.26 Laptop shelves shall be fitted to the inside of the RTU compartment door. Shelves shall be constructed as per Unitywater's standard switchboard drawings.

8.4. Switchboard arrangement

- 8.4.1 Switchboard equipment shall be arranged so that no piece of equipment which is to be operated or viewed by an operator (push buttons, switches, meters) shall be mounted more than 1900 mm or less than 400 mm from ground level.
- 8.4.2 All equipment mounted on the equipment panel must be capable of being removed whilst standing in front of the respective equipment panel without having to disassemble or remove items not forming an integral part of that individual piece of equipment.
- 8.4.3 All electrical equipment in the cabinet shall be mounted either on the equipment panel or on the escutcheon. Equipment mounted on the cabinet floor, ceiling or sidewalls is not acceptable. Exceptions to these requirements will only be made for equipment such as door switches, internal light fittings and fans where the function of the equipment requires it to be mounted elsewhere.
- 8.4.4 All equipment shall be installed in such a manner that all necessary electrical clearances are observed and that equipment is grouped logically in accordance with Unitywater's standard switchboard drawings.
- 8.4.5 All live parts (including terminals, busbars and control devices and meters mounted on switchboard doors) which are behind hinged, non interlocking doors or escutcheons and which carry a voltage greater than 24 V shall be shrouded to IP2x to protect against accidental contact when the enclosure doors or escutcheons are open. Warning labels shall be provided on shrouds.

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- 8.4.6 Telemetry equipment shall be located and installed in a separate compartment from the switchgear and control gear in accordance with Unitywater's standard switchboard drawings. The compartment shall be suitably sized to accommodate the required hardware and connection terminals.
- 8.4.7 Supply Authority Metering shall be located and installed in a separate compartment from the switchgear and control gear in accordance with Unitywater's standard switchboard drawings. The compartment shall be suitably sized to accommodate the required metering hardware and test blocks as per Supply Authority requirements.
- 8.4.8 A single 240V 15A socket outlet shall be provided on the front panel of the switchboard. A residual current device (RCD) circuit breaker of 30 mA sensitivity shall be provided for the socket outlet.
- 8.4.9 A double 240V 10A socket outlet shall be provided in the telemetry section of the switchboard. A RCD circuit breaker of 30 mA sensitivity shall be provided for the socket outlet.

8.5. Switchboard wiring

- 8.5.1 All power wiring within the switchboard shall be installed in flexible V90-HT grade PVC insulated multi-strand tinned copper conductors of minimum size 2.5 mm² (50/0.25 mm) – suitable ferrules or pin terminators shall be crimped onto the conductor before connection.
- 8.5.2 All 240VAC control wiring within the switchboard shall be installed in flexible V90-HT grade PVC insulated multi-strand tinned copper conductors of minimum size 1.0 mm² (32/0.20 mm) – suitable boot lace ferrules shall be crimped onto the conductor before connection.
- 8.5.3 All 12/24VDC battery and ELV distribution wiring within the switchboard shall be installed in flexible V90-HT grade PVC insulated multi-strand tinned copper conductors of minimum size 1.0 mm² – suitable boot lace ferrules shall be crimped onto the conductor before connection.
- 8.5.4 All 12/24VDC telemetry wiring within the switchboard may be installed in flexible V90-HT grade PVC insulated multi-strand tinned copper conductors of minimum size 0.5 mm², although consideration must be given to the protective device feeding this sized conductor and sized according to AS3000 and AS3008, and all wiring shall have suitable boot lace ferrules crimped onto the conductor before connection.
- 8.5.5 All analog wiring within the switchboard shall be installed in individual and overall screened twisted pair instrument cabling of minimum size 0.5 mm².
- 8.5.6 Cable insulation for all control and power cabling shall be V90-HT 0.6/1 kV.
- 8.5.7 All low voltage (LV) cables entering the extra low voltage (ELV) sections of the switchboard shall be double insulated.
- 8.5.8 All conductors shall be terminated with approved crimping lugs or crimping pins. Crimping lugs or pins shall be applied using an approved, certified tool with a ratchet action. Separate lugs or pins shall be used for each conductor. The size of the lug or pin shall be suited to the size of the conductor being terminated.
- 8.5.9 There shall be no joining or teeing of wires between terminals.
- 8.5.10 Not more than two wires shall be connected to any one terminal.

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- 8.5.11 Terminal bridging shall be achieved using proprietary comb or terminal bridging rails.
- 8.5.12 Not more than one wire shall be connected to one side of any tunnel type terminal. Multiple tunnel type terminations shall use proprietary terminal link bars.
- 8.5.13 Grafoplast or equivalent ferrules shall be fitted at each end of all separate lengths of control wire. Ferrules shall have black alpha/numeric characters on a background of white insulating material. Saddle type clip-on ferrules shall not be used. Ferrules shall be arranged to read from left to right and from bottom to top. Wires shall be numbered in accordance with the contract drawings.
- 8.5.14 Connections to external control wiring and auxiliaries shall be through numbered terminal strips. Terminals shall utilise a screw-tightening mechanism. Every terminal shall be large enough to accept at least 4 mm² cables. Terminals for connection of Thermistor wiring shall be clearly labelled with the name of the item of equipment and the test voltage. Terminals of strips or equipment shall not bite or indent the wire end, but shall clamp the wire with a plate or use solderless crimp lugs. Every terminal for control wiring shall be capable of accepting at least two control wires.
- 8.5.15 All terminal strips shall be mounted horizontally.
- Switchboard wiring shall be colour coded as per
- 8.5.16 **Table 1 - Colour Code for Switchboard Wiring** below.

Table 1 - Colour Code for Switchboard Wiring

Circuit Type	Wire Colour
415V Supply A Phase	Red
415V Supply B Phase	White
415V Supply C Phase	Blue
AC Supply Neutral	Black
240VAC Control	Red
240VAC Control Neutral	Black
24VDC +	Purple
24VDC -	Grey
12VDC +	Purple
12VDC -	Grey
Analogue (4-20mA) - Where Dekoron Used	Dekoron Black/White paired
Telemetry +	Purple
Telemetry -	Grey
Thermistor	Orange
Earth	Green/Yellow

Note: where practical all 240VAC circuits are to be fed from the red phase and kept in red. The only time this shall not occur is where a major imbalance would

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occur in which case typical distribution shall occur across all 3 phases. In this case the phase colour shall be used.

8.5.17 The following wire numbering convention shall be used for all switchboards:

- 0-99 – AC Power Circuits;
- 100 Series – Pump 1 Circuits;
- 200 Series – Pump 2 Circuits;
- 300 Series – Pump 3 Circuits;
- 400 Series – Pump 4 Circuits;
- 500 Series – DC Circuits;
- 600 Series – RTU I/O;
- 700 Series – As required;
- 800 Series – As required;
- 900 Series – Common Control Circuits.

8.6. Disconnection cubicle

8.6.1 Where the well is remote from the switchboard either visually or by more than 10 meters, a separate disconnection cubicle shall be designed, supplied and installed as per Unitywater's standard electrical drawings and this specification.

8.6.2 The disconnection cubicle shall be effectively sealed to prevent the ingress of gases from the well. This shall be achieved by ensuring the base plate of the section above the cable termination zone is sealed by being fully welded. The cables shall enter the cubicle via approved sealed glands. The base plate shall be sealed except for the motor and control cable gland holes. Space should be available to add cables or increase the size of existing cables. All unused holes must be sealed mechanically. Adequate cable supports shall be supplied in this termination zone.

8.6.3 Disconnection cubicles shall be constructed generally in accordance with the requirements for switchboard construction listed in Section 8.3 unless otherwise noted in this specification or the project specifications.

8.7. Switchboard Cable Zones

8.7.1 Unless otherwise specified by standard drawings issued with this specification, motor control centres shall be supplied with vertical cable zones adjacent to each tier and with a horizontal wiring enclosure running along the length of the board.

8.7.2 Adequate access shall be provided from each vertical zone to the wiring enclosure.

8.7.3 Cable zones shall be adequately sized, shall be of minimum opening width 300 mm and shall be designed for ease of installation and maintenance of cables.

8.7.4 Cable trays shall be mounted over the full length of all cable zones to allow fastening of cables.

8.7.5 Cable ways shall be provided as necessary to ensure that apart from interconnections no cable routed to one compartment shall pass through any other compartment. Equipment shall not be located within the cableways.

8.7.6 All cable entries shall be effected using glands.

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9. Installation

9.1. Switchboard installation

- 9.1.1 Switchboards shall be mounted on a concrete plinth and secured using at least four (4) stainless steel masonry fasteners of not less than 12 mm diameter. Chemset fasteners are suitable for this application.
- 9.1.2 Switchboards and disconnection cubicles shall be positioned so that the doors do not open over the wet well access hatch or in a location where a fall may occur.

9.2. Conduit installation

- 9.2.1 Conduit used throughout the electrical installation shall comply with the relevant Australian Standards whether it is PVC rigid, PVC flexible or steel.
- 9.2.2 Conduits shall be concealed unless otherwise agreed to by the Contract Superintendent. Where it is necessary to use exposed conduit a neat installation will be insisted upon. Conduit exposed on painted structures shall be painted to the same colour as the structures.
- 9.2.3 Conduit shall be not less than 25 mm in diameter.
- 9.2.4 Draw rope shall be installed in all conduits including conduits containing cables. Draw rope shall be braided orange polyethylene, or prior approved equivalent.
- 9.2.5 Power and instrument conduits shall be separated by a minimum of 300 mm.
- 9.2.6 Conduits shall be installed to avoid all mechanical duct systems and other pipe services. The conduit shall be laid as far as possible in straight lines with easy sets or long radius bends. Where conduit is to be bent, it must be bent without altering its section.
- 9.2.7 Jointing of PVC conduit and fittings shall be carried out strictly in accordance with the manufacturer's recommended jointing method. Expansion joints shall be installed in all PVC runs, at intervals not exceeding the Australian Standards and manufacturer's recommendations.
- 9.2.8 During building operations and/or installation of electrical work, the open end of all conduits shall be tightly plugged to prevent the ingress of moisture and foreign matter. The open ends of conduits shall be interpreted as meaning not only the open ends of conduit runs during process of installation, but shall also include the open ends of conduits where such conduit terminates in boxes and the like.
- 9.2.9 The conduit is in no part to be under mechanical stress.
- 9.2.10 In concrete slabs, outlet boxes for fittings shall be used as draw boxes. The maximum runs of conduit without a draw-box shall not exceed 12 meters.
- 9.2.11 Conduits shall not touch any other pipes and shall in all cases, be at least 450 mm from heating or gas pipes.
- 9.2.12 Fittings used with PVC conduit shall be PVC.
- 9.2.13 For metallic conduit, screwed metallic fittings shall be used. Galvanising shall be carried out after the fittings are threaded.
- 9.2.14 Conduits where run on the surface of walls and ceilings shall be fixed by means of stainless steel double-sided saddles and stainless steel screws (2 stainless steel

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- screws per saddle). Such fixings shall be at intervals not exceeding 800 mm. Explosive or hammer-in type fasteners will not be accepted for fixing.
- 9.2.15 Support brackets, where necessary, shall be 316 grade stainless steel or marine grade aluminium.
- 9.2.16 Cables and conduits shall be grouped as far as possible and all supports, clips, saddles and brackets spaced to prevent appreciable sag.
- 9.2.17 Conduit requirements between the switchboard and well shall be as follows:
- One (1) conduit for each pump cable being a minimum of 50 mm in diameter or three times the outside diameter of the installed cable, whichever is the greater;
 - Minimum of one (1) conduit for instrument cables being a minimum of 50 mm in diameter.
- 9.2.18 Conduits shall be arranged within the switchboard as per Unitywater's standard electrical drawings.
- 9.2.19 No conduit entries are to be made through the switchboards outer casing unless approved in writing by the Superintendent.
- 9.2.20 Conduits entering a switchboard, trench, cable pit or switchroom shall be effectively sealed at the switchboard end using Henley's Plastic Compound, Denso Mastic or approved equivalent to form a re-enterable water and gas tight seal.
- 9.2.21 All openings made for entry of electrical conduits or ducts and the like into buildings, trenches, cable pits and cableways, shall be effectively sealed with a waterproof concrete grout, or other approved means.
- 9.2.22 All spare conduits and ducts shall be plugged and sealed.
- 9.2.23 All conduits entering the well shall be individually cast or cored through the well wall. Core holes shall be sealed around conduit with an approved epoxy coating.
- 9.2.24 Before proceeding with excavation work, the details of all existing underground services and those to be installed in the area shall be ascertained. The Contractor is responsible for lodging an enquiry with Dial Before You Dig (www.1100.com.au) and must not commence excavation works until all information has been received from identified parties.
- 9.2.25 Conduits laid under roadways shall project 0.5 meters beyond the back of the kerb. They shall be heavy duty rigid PVC conduit suitable for underground installation and shall be supplied and installed unless otherwise stated.
- 9.2.26 Conduit shall be laid at a minimum depth in accordance with AS/NZS 3000 in a clean bed of sand providing minimum 100 mm cover above conduit. A polymeric cable protection cover shall be laid over the entire length at a depth of 300 mm. Care shall be taken when laying the cover around curves and bends. The trench is to be backfilled and consolidated to finished ground level.
- 9.2.27 Reinstatement of turf shall be necessary when trenching is completed in "sensitive areas", e.g. outside domestic property, through parkland or as specified by the Contract Superintendent.
- 9.2.28 Cable pits are to be adequately drained through a sump well.

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9.3. Cable installation

- 9.3.1 Cable installation methods shall comply with the Supply Authority regulations and all relevant Australian Standards.
- The following methods of cable identification shall be used:
 - *Indoor Cables* Nylon/Plastic Black on Yellow
 - *Outdoor Cables* Black on 316 grade stainless steel tags with stainless steel ties
 - (Ties must be tied off with appropriate tool).
- 9.3.2 Cable numbers on stainless steel tags shall be engraved.
- 9.3.3 All cables leaving the switchboard shall be labelled at both ends.
- 9.3.4 Power and instrument cables are to be separated by a minimum of 300 mm.
- 9.3.5 Cables shall be installed to minimise the effects of electromagnetic interference and harmonic interference.
- 9.3.6 Cables shall leave their respective starters via isolators located at low level within the switchboard or other approved locations. The cables shall exit via the bottom of the cubicle and shall run via cable trays and/or conduits to their respective equipment.
- 9.3.7 All cables passing into or from the cable entry compartment or field equipment shall be individually glanded. Cable glands are to be selected to suit the cable type so that a gas tight seal is achieved.
- 9.3.8 Cables shall be carefully installed to avoid damage to the sheathing and to any structure or support system. All ducts and conduits shall be clear before any cables are pulled through. Cable guides shall be used to prevent damage to cables being pulled. When pulling cables, lubricating products designed specifically for pulling cables shall be used.
- 9.3.9 Cabling external to the switchboard shall be run on cable trays or in conduit to the requirements of this specification and any project specifications. UV exposed cabling will not be accepted.
- 9.3.10 Joints in cables will not be permitted unless specified in the project specifications or authorised in writing by the Contract Superintendent. The Contractor shall submit the proposed joining method for approval.
- 9.3.11 Final sub-circuits to motors shall be sized, for full load motor current plus 20 %.
- 9.3.12 Separation of electrical power (low voltage and above) cabling from data communication and instrumentation cabling shall be achieved through separate cableways and conduits. However, where this is not practical, a metal divider barrier shall be installed on the cable ladder to separate these cables.

9.4. Mains and sub-mains

- 9.4.1 The Contractor shall provide, install and terminate a powder coated galvanised steel service/vent pole as per Unitywater's standard drawings for the point of attachment at all sites with overheads supplies.

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- 9.4.2 Where the supply to the switchboard is underground, the Contractor shall ensure that the Supply Authority's power supply pillar is installed adjacent to the pumping station.
- 9.4.3 The Contractor shall provide, install and terminate all required mains and sub-mains cabling. All cabling shall be PVC/PVC or XLPE multicore copper unless other types are approved in writing by the Contract Superintendent.
- 9.4.4 All mains and sub-mains shall be a minimum of 16 mm² cables and shall maintain double insulation to the metering section.
- 9.4.5 Mains cables shall be routed within the switchboard so as to maintain segregation from other wiring wherever possible.

9.5. Motor and pump cabling

- 9.5.1 All non-VSD (variable speed drive) motor cabling shall be PVC/PVC, 0.6/1 kV multi-stranded copper multicore, V-90 thermal rating sized in accordance with AS 3008.1.1 for voltage drop or full load motor current plus 20 % whichever is the more severe duty.
- 9.5.2 A motor fed from a VSD shall have a shielded cable suitable for VSD operation. Length of cable run shall be checked for reflected wave voltage amplitudes and approved motor terminators shall be used where cable length is greater than recommended maximum lengths. Where the cable passes through a disconnection cubicle the earth shield shall be continuous to the drive and isolated from local earth.
- 9.5.3 Submersible pump cables shall be manufactured to the requirements of AS/NZS 5000 and meet the test criteria as described in AS/NZS 1660. A Certificate of Compliance shall be submitted prior to installation.
- 9.5.4 The cable shall be suitable for use in wastewater applications.
- 9.5.5 Cables shall be adequately supported within the pump well with individual stainless steel support brackets and stainless steel cable socks for each motor cable to avoid interference with access, pump servicing and the normal operation of the station.

9.6. Cable trays and ladders

- 9.6.1 Cable trays, brackets and ladders shall be fabricated from marine grade aluminium and shall be adequately supported and fixed in position as per manufacturer's instructions.
- 9.6.2 Cable trays and ladders shall be a minimum of medium duty and be rated to support a load of 75 kg per linear metre. Maximum span shall be 3 m unless otherwise approved by the Contract Superintendent. Cable trays shall be of the expanded metal type of 2 mm thickness with edges trimmed in a continuous metal envelope. Standard tees, crosses and bends shall be used with the cable tray. Where necessary for segregation of different type cables, full depth barriers shall be supplied and securely fitted.
- 9.6.3 All external cable trays and ladders shall have aluminium UV protection covers installed. All horizontal runs the covers shall be peak and for vertical shall be flat.
- 9.6.4 Edges and openings in cable trays shall be protected to prevent cable damage. The method of protection shall be subject to approval.
- 9.6.5 Tray fasteners shall not be explosive driven types without written approval.
- 9.6.6 Tray supports shall be fitted with a minimum of two fasteners.

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- 9.6.7 Cable tray entry into buildings shall be sealed to prevent rodent access using Henley's compound or equivalent.
- 9.6.8 Cables shall be securely tied to the trays with UV protected cable ties at maximum 300 mm centres. Cable ties shall be Thomas & Betts or equivalent.
- 9.6.9 No cable crossovers, excepting where cables enter or leave the trays, will be permitted.
- 9.6.10 All metallic tray or ladder sections shall be joined to achieve equipotential bonding to the main earth system. The Contractor shall test the installation as part of the SAT.

9.7 Mechanical protection

- 9.7.1 The Contractor shall supply and install approved mechanical protection on all electrical equipment including conduits and cable tray under the following conditions:
 - 9.7.2 When mounted within 1.5 meters above a floor or access platform;
 - 9.7.3 Where subject to damage during normal plant operation and maintenance;
 - 9.7.4 Areas on which scaffolding and / or planks may be placed or which may be used as means of access for abnormal plant maintenance.
- 9.7.5 Conduits and/or cables (other than single core cables) requiring mechanical protection shall be installed in galvanised steel water pipe or other prior approved means.
- 9.7.6 Sheet metal covers installed to provide mechanical protection of electrical equipment shall be constructed to withstand the shock loading likely to occur in the area. Covers shall be constructed of a minimum 3 mm marine grade aluminium material or other approved metal.
- 9.7.7 Sheet metal covers installed to provide mechanical protection of electrical equipment shall be constructed so as to totally enclose such electrical equipment and associated conduits and/or cables.
- 9.7.8 Any device installed for the mechanical protection of conduits and/or cables shall be free of burrs and sharp edges. Additional bushing, sleeving or other prior approved means shall be provided as required to ensure adequate bending radius and to prevent conduit and/or cable damage.
- 9.7.9 Covers shall be easily removed to facilitate maintenance and repair. Explosive or hammer-in type fasteners will not be accepted as fixing for covers.

10. Earth Neutral Connection and Surge Protection

10.1. Earth neutral connection

- 10.1.1 The Contractor shall be responsible for the earth system installation and reticulation, which shall comply with the supply authority requirements and relevant Australian Standards.
- 10.1.2 The main earth rod shall be installed in an earth pit as listed in [F10678](#) – Accepted Electrical Equipment List. The top of the earth pit shall be level with the top of the concrete slab.

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- 10.1.3 The earth bar shall be provided within the switchboard, with minimum 20 % spare (unused) connections.
- 10.1.4 The neutral bar shall be provided with minimum 20 % spare (unused) connections and shall be fully labelled at each termination.
- 10.1.5 The earth and neutral busbars shall be clearly labelled.
- 10.1.6 A M.E.N. link sized to AS/NZS 3000 shall be provided in the main switchboard only and labelled as such. Neutral and earth busbars shall be completely isolated from each other, except for the M.E.N. link.

10.2. Lightning and surge protection

- 10.2.1 All equipment shall be protected from lightning and power surges. The protection system shall consist of surge protection devices and earthing systems. The protection system should not affect the operation of equipment under normal operating conditions.
- 10.2.2 All surge protection systems shall be installed in accordance with the manufacturer's recommendations and all relevant Australian Standards.
- 10.2.3 Earthing conductors shall be a minimum size of 6 mm² and the maximum resistance between protected components and the earthing mat or electrode shall be 0.1 Ω. The Contractor shall install the required earthing electrodes and conductors. Surge protection devices installed remotely from a switchboard shall be connected to a local earth electrode.
- 10.2.4 Shunt surge diverters shall be supplied and installed on the main 3-phase bus of the switchboard after the Main Switch or immediately after the supply changeover switch if fitted. They are to be connected between each phase and the neutral bar by the shortest most direct route using straight copper bar or cables with a minimum cross sectional area of 35 mm².
- 10.2.5 Suitable fuses, in accordance with the manufacturers' recommendations shall be installed between the mains and the surge diverters where the consumer's mains are protected by fuses rated at or more than 63 A.
- 10.2.6 The diverters shall be rated at a minimum of 275 V RMS. The devices shall be encapsulated in shock absorbent material and have 250 V AC isolated alarm contacts. The diverters shall be rated to suit the fault current of the switchboard. The Contractor shall submit fault current calculations to the Contract Superintendent with the switchboard drawings. The devices shall have a design capability of withstanding and diverting at least 1000 V for a 20 kA Cat C pulse.
- 10.2.7 Where a site consists of a main switchboard and a number of sub-switchboards, which are located separately in other buildings or via sub main cables in excess of 20 m, the above surge diverters shall be installed on each switchboard.
- 10.2.8 A surge reduction filter rated at a minimum of 10 A shall be provided in each switchboard. The unit shall incorporate filters on the active and neutral lines. This device shall supply power to all control, instrumentation and telemetry equipment within the switchboard or the same building only.
- 10.2.9 Remote equipment in a separate building or switchboard where supplied from an unfiltered circuit shall have a surge suppression device at its remote termination.

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10.3. Instrumentation protection

- 10.3.1 Surge protection devices shall be provided on all instruments external to the switchboard at both ends of the 4-20 mA signal cables and digital data lines that clamp the voltage to no more than 45 V.
- 10.3.2 Each device shall be securely bonded to the earthing system. The housing of each transmitter and each receiver shall be connected to the earthing system. Remote transmitters shall use a local earth system.
- 10.3.3 Surge protection devices are not required if the signal loop does not extend outside of the switchboard or the confines of a building.
- 10.3.4 Surge protection devices shall be of the series connected type, comprising three stages of protection: fail-safe operation (fail to short circuit), common and differential mode protection.

10.4. Instrument earthing

- 10.4.1 All instruments shall be earthed in accordance with the manufacturer's recommendations and the relevant Unitywater standard electrical drawings.

10.5. Coaxial antenna cable protection

- 10.5.1 Coaxial antenna cables shall be protected by coaxial surge protectors suitable for the frequency of operation of the antenna system. The surge protector shall be securely bonded to ground via clean metal to metal contact with the equipment panel and an earth cable.

11. Lighting

11.1. Switchboard lighting

- 11.1.1 Light fittings shall be mounted inside the switchboard. The number of light fittings and their positioning within the switchboard shall be as per Unitywater's standard electrical drawings. For non-standard switchboards, the fittings shall provide equivalent illumination.
- 11.1.2 The type and rating of the light fittings shall be as per Unitywater's [F10678](#) – Accepted Electrical Equipment List.
- 11.1.3 Switchboard lights shall be controlled by a common switch mounted on the escutcheon of the switchboard compartment housing the lighting circuit breakers.

11.2. Area lighting

- 11.2.1 Area lights are to be mounted on the vent pole as per Unitywater standard drawings. Where no vent pole is installed, area lighting shall be as per the site specific requirements.
- 11.2.2 Fittings shall be anti-vandal impact resistant polycarbonate diffusers.
- 11.2.3 Area lights are to be mounted to allow easy access for maintenance purposes.

11.3. Building lighting

- 11.3.1 Pump Station buildings shall be illuminated as per Australian Standards.

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- 11.3.2 Fittings shall be selected from the Unitywater [F10678](#) – Accepted Electrical Equipment List and installed using a minimum of four #8 gauge stainless steel screws per fitting.
- 11.3.3 Consideration is to be given to the positioning of the lights for maintenance purposes. Confirmation of lighting positions is to be obtained from the Contract Superintendent prior to final design and installation.
- 11.3.4 Light switches shall be mounted in a heavy-duty housing and shall be positioned adjacent to the closing stile of doors. Confirmation shall be obtained as to the hand of doors before installing any switch wiring.
- 11.3.5 Fixtures shall be carefully and neatly installed complete with all necessary connectors; adjustable mountings brackets and trim, as required for ceiling conditions. All labels and marks shall be removed from the exposed parts of the fixtures.
- 11.3.6 Fixtures shall be cleaned when the job is complete.
- 11.3.7 Emergency lighting shall be installed as per the appropriate Australian Standard.

12. Auxiliary Power Requirements

12.1. General

- 12.1.1 The Contractor shall make provision for the connection of auxiliary power supply to Unitywater Network Sites as specified by Unitywater.

12.2. Temporary generator installations

- 12.2.1 For temporary generator installations, a manual changeover switch shall be provided to allow a generator to supply power to the switchboard.
- 12.2.2 The power inlet shall be located on the side of the switchboard in accordance with the Unitywater standard electrical and site specific drawings. Where site restrictions require departures from the standard drawings, approval shall be sought from the Contract Superintendent or their nominated representative.
- 12.2.3 The generator inlet plug shall be wired to match the mains phase rotation.
- 12.2.4 Connection methods to be used for temporary generator installations are as per **Table 2 – Temporary Generator Connections** below:

Table 2 - Temporary Generator Connections

Switchboard Size	Connection Type
0-25kW	NHP Proconnect Plug (63A)
25-60kW	NHP Proconnect Plug (125A)
Above 60kW	Connection box utilising Powersafe connectors

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12.3. Permanent generator installations

- 12.3.1 For permanent generator installations, an Automatic Transfer Switch (ATS) shall be provided to allow automated changeover to generator power supply to the switchboard upon loss of mains supplies.
- 12.3.2 ATS systems shall be as per Unitywater's [F10678](#) – Accepted Electrical Equipment List and standard electrical drawings.
- 12.3.3 Connection to the switchboard and automatic switching equipment shall be in accordance with Unitywater's standard electrical drawings. The Contractor shall provide all wiring between the switchboard and the generator.
- 12.3.4 Generators shall be supplied and installed as per Project Specifications.

13. Electrical Equipment

13.1. General

- 13.1.1 All electrical equipment shall be selected from Unitywater's [F10678](#) – Accepted Electrical Equipment List. Where the required piece of electrical equipment is not on the list approval shall be sought from the Contract Superintendent.
- 13.1.2 Equipment supplied shall possess maximum possible built-in safety features.

13.2. Main switch

- 13.2.1 Each switchboard shall be fitted with a three phase main isolating switch and shall have a fault rating greater than the fault level at the consumers' terminals as determined by the Supply Authority.
- 13.2.2 Main switches shall be of the auto or non-auto circuit breaker type.
- 13.2.3 The main switch shall be interlocked to prevent the door being opened with the switch closed or the switch being closed with the door open. However, provision shall be made for authorised personnel to defeat the interlocks for test purposes. Provision shall also be made for padlocking the switch in the OFF position with the door open or closed.
- 13.2.4 A label shall be fixed adjacent to the main switch identifying the electrical pillar box or pole number to which the pump station is connected.

13.3. Emergency supply transfer switch

- 13.3.1 Manual transfer switches shall be supplied with an emergency position auxiliary contact for remote telemetry indication.
- 13.3.2 Automatic transfer switches (ATS) shall be supplied with normal and emergency position auxiliary contacts for remote telemetry indication.

13.4. Circuit breakers

13.4.1 General

- 13.4.1.1 All outgoing circuits shall be protected by circuit breakers affording Type 2 Coordination. The circuit breakers shall be typically of the following types for particular current ratings:
 - Current ratings up to and including 100 A – miniature circuit breakers;

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- Current ratings between 100 A and 1200 A – moulded case circuit breakers;
- Current ratings over 1200 A – air circuit breakers.

13.4.1.2 Notwithstanding the above list, the Contractor shall still be responsible for calculating the prospective fault currents and ensuring that the circuit breakers installed proved the required protection and coordination.

13.4.1.3 Circuit breaker chassis, where applicable, shall have a minimum of 20 % spare capacity. The circuit breaker chassis shall be of proprietary manufacture of the same make and model as the circuit breakers being supplied and connected.

13.4.1.4 Circuit breakers shall be installed in a cubicle or compartment where specified or shown on the drawings. The circuit breakers shall be logically ordered and shall be installed on the appropriate chassis or as a bus-bar/plug connection depending on the required Form of Enclosure to AS 3439.1. Each circuit breaker shall be labelled as per the electrical schematics and shall be padlockable in the OFF position.

13.4.1.5 All circuit breakers within the one installation shall be of the same make.

13.4.2 Moulded Case Circuit Breakers

13.4.2.1 The Contractor shall ensure that all circuit breakers are correctly sized to protect the downstream equipment against overload and fault conditions.

13.4.2.2 Circuit breakers shall be capable of horizontal or vertical mounting. Horizontally mounted circuit breakers shall have been fully tested as being capable of successfully operating under full load and short circuit conditions in the horizontal position.

13.4.2.3 Multi-pole breakers shall interrupt all phases via a common tripping mechanism for a single-phase fault and be interchangeable with 3 single poles for 1 triple pole and vice-versa.

13.4.2.4 Circuit breakers shall comply with AS 3111.

13.4.2.5 Circuit breakers shall be selected in accordance with the manufacturers recommended cascade co-ordination chart, Category II only.

13.4.2.6 Circuit breakers shall incorporate the following features:

- Padlockable in the OFF position;
- Handles shall have an intermediate trip position.

13.4.3 Air Circuit Breakers

13.4.3.1 Air circuit breakers shall include at least the following functionality:

- Withdrawable arrangement;
- Adjustable over current release mechanism;
- Padlockable handle in the 'OFF' position;
- Position indication.

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13.5. Fuse fittings and cartridges

- 13.5.1 Fuses shall be HRC type and shall be suitable for the fault level of the installation. All fuse cartridges (excluding those mounted in fuse combination units and fault current limiters) shall be held in a fully enclosed moulded fuse holder with shrouded contacts and provide safety to the operator while withdrawing the carrier.
- 13.5.2 Fault current limiter cartridges shall be held in approved holders and shall be readily accessible. Where fuse extraction handles are required, they shall be clipped inside the cubicle adjacent to the fuses. Where the fuses are located behind more than one cover, one handle shall be provided behind each cover.
- 13.5.3 At least one 3 phase set of fuses for every size included in the switchboard shall be mounted in fuse clips with individual fuse size labels in a spare fuse rack on the inside of one of the doors.

13.6. Current transformers

- 13.6.1 Current transformers shall be resin encapsulated window type and shall comply with AS60044.1.
- 13.6.2 Unless otherwise indicated, the following details shall apply:
- Rated primary current shall have a current rating equal to the maximum current rating of the frame size of the controlling device;
 - Secondary windings of measurement current transformers shall be rated at 5 A. The burden shall be 0.4 Ω (10 VA) minimum and the accuracy shall be class 2 minimum.

13.7. Motor selector switch

- 13.7.1 A Manual-Off-Auto selector switch shall be installed for each pump controlled from the switchboard. The following functionality shall apply:
- The manual position shall start the drive motor on selection;
 - Off position stops the drive and prevents starting in Auto mode;
 - Auto position allows control system to operate the drive.
- 13.7.2 Selector switches shall be mounted with the Auto position to the right.

13.8. Isolating switches

- 13.8.1 Isolators shall have a facility for padlocking the switch in the OFF position with the door open or closed. This facility must be an integral part of the switch and the operating handle.
- 13.8.2 Isolation switches shall be provided with one set (N/O & N/C) of early break, late make auxiliary contacts. One contact shall be utilised to provide remote indication of motor isolation.

13.9. Contactors

- 13.9.1 Contactors shall be rated in accordance with AS/NZS 3947 and shall be classified as follows:
- Duty - uninterrupted and intermittent Class 12;

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- Utilisation Category – AC-3;
- Minimum no load operating cycles - 3.0 million.

13.9.2 Each contactor shall have a means of mechanical indication to show when it is energised and shall be equipped with a suitable number of auxiliary contacts for control and monitoring purposes.

13.9.3 Contactors shall be moulded block type construction incorporating double break contacts with arcing enclosures. Coils shall be continuously rated to operate at 24 V DC. Main contactors shall have a minimum of two auxiliary contacts (1 x N/O, 1 x N/C) over and above what is required for the control circuits. It shall be possible to install additional auxiliary contacts to any contactor.

13.9.4 Motor contactors shall be equipped with electronic overload as per Clause 13.11 of this specification.

13.10. Power monitoring

13.10.1 Power monitoring is to be performed by a power meter. The power meter shall comply with the Unitywater [F10678](#) – Accepted Electrical Equipment List.

13.10.2 Three (3) single pole suitably sized circuit breakers are to be used to isolate the line side of the meter as per Unitywater's standard electrical drawings.

13.11. Motor overload and thermistor protection

13.11.1 For DOL controlled stations motor overload protection shall be provided by thermal overload devices in accordance with AS 60947. This device shall be fitted to the pump contactors.

13.11.2 The thermal overload device shall be based on full load current with an adjustment on the current to trip. The device shall also afford protection against out-of-balance currents.

13.11.3 All overload devices shall be auto-resetting and have test facilities.

13.11.4 For soft starter and VSD controlled stations the motor overload and thermistor protection shall be incorporated in the motor drive or starter, as detailed in this specification.

13.12. Relays and timers

13.12.1 Relays shall be fully enclosed, plug-in type and be suitable for DIN rail mounting. Relays shall be rated for continuous operation and the contacts shall be rated at 10 A 250 V. Relays shall incorporate a test push button and inbuilt LED to indicate when the relays are energised. Relays shall have 4 poles per relay.

13.12.2 Timers shall be solid state, plug-in type and be suitable for DIN rail mounting. Timers shall be rated for continuous operation and the contacts shall be rated at 10 A 250 V.

13.13. Power failure monitoring

13.13.1 Power failure monitoring is to be performed by a dedicated phase failure relay (PFR). The PFR shall be selected from Unitywater's [F10678](#) – Accepted Electrical Equipment List. The PFR shall also monitor phase sequence.

13.13.2 The PFR shall be isolated on the line side by three (3) single pole circuit breakers as per Unitywater's standard electrical drawings.

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13.13.3 The PFR shall be DIN rail mountable.

14. Motor Starters

14.1. General

- 14.1.1 The following starter types shall be supplied for the specified motor sizes:
- 0-4 kW – Direct On Line (DOL) starter;
 - Above 4 kW – Electronic Soft Starter unless specified as VSD.
- 14.1.2 Electronic starters shall be mounted in accordance with manufacturer's instructions. The recommended free space shall be provided around the starter for cooling purposes. If necessary, additional cooling shall be provided. Fan ventilated enclosures shall operate under positive pressure. High quality replaceable filters shall be provided to dust proof the air intakes.
- 14.1.3 Care shall be taken to segregate power, control and motor cables.
- 14.1.4 Starters shall be designed for utilisation category AC3 and an intermittent duty of up to 12 starts per hour.
- 14.1.5 Unless noted otherwise in the Project Specification, all motors shall have Type 2 coordination between the circuit breaker, contactors and any protective devices.
- 14.1.6 All DOL starters shall be sized for a pump size of 4 kW.

14.2. Soft starters

- 14.2.1 Electronic Soft starters shall be selected from the Unitywater [F10678](#) – Accepted Electrical Equipment List. One (1) electronic soft starter shall be supplied, installed and connected for each pump supplied from the switchboard.
- 14.2.2 The starter shall be capable of starting the motor six (6) times per hour for motors rated greater than 50 kW and twelve (12) equally time spaced starts per hour for motors rated at 50 kW or less with an on-time of 90 % dependent upon nonoperational time for acceleration and deceleration.
- 14.2.3 Controlled deceleration of the motor during stopping shall be provided where specified in the Project Specification.
- 14.2.4 Soft Starters shall be supplied with internal bypass contactors and rated for severe duty.
- 14.2.5 Soft Starters shall be supplied with 24 V DC control voltage.
- 14.2.6 Terminals shall be provided on the starter for the connection of motor thermistors.
- 14.2.7 Soft starters shall be supplied with a LCD display/keypad capable of being mounted remote from the starter.
- 14.2.8 The LCD display panel shall be mounted remote from the unit. The remote panel shall protrude through the escutcheon or door to allow direct operator access.
- 14.2.9 All communication cables shall be shielded.

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14.3. Variable Speed Drives

14.3.1 General

- The term Variable Speed Drive shall be taken to include the following alternate terminology for motor starters providing stepless variable control of the operating speed of an electric motor:
- Variable Speed Drive (VSD);
- Variable Frequency Inverter (VFI);
- Variable Frequency Drive (VFD);
- Variable Voltage Variable Frequency (VVVF).

Note: This specification shall use the term Variable Speed Drive or VSD.

- 14.3.1.1 Variable Speed Drives shall be installed for all installation above 25kW to assist with power factor correction. VSD units shall be selected from the Unitywater [F10678](#) – Accepted Electrical Equipment List.
- 14.3.1.2 A motor fed from a VSD shall have a shielded and appropriately earthed cable suitable for VSD operation.
- 14.3.1.3 One copy of the PC software in CD format and communications cable shall be provided per site to set up drives.
- 14.3.1.4 All settings which differ from the default settings within the VFD shall be recorded on the electrical drawing set.

14.3.2 Control and Indication

- 14.3.2.1 The VSD shall have a keypad to facilitate programming, diagnosis and control of the VSD. The keypad shall be remotely mounted on the cubicle door Adjacent to all other pump/motor controls and indicators.

14.3.3 Switchboard Mounted VSDs

- 14.3.3.1 The switchboard shall be provided with adequate ventilation to ensure internal temperature does not exceed the VSD recommended maximum temperature. If required, fans shall be installed on cubicle doors and be mounted directly behind an inlet vent provided with a grill. Easily demountable filters shall be provided inside the door, and contained in a rigid frame for repetitive cleaning. Dry-type fine particle heavy-duty filters shall be used.
- 14.3.3.2 The inlet air flow, with the filter at its intended maximum dust load and all doors shut, shall equal the design flow rate of the cooling air for the VSD.
- 14.3.3.3 When the VSD is to be located inside a switchboard an IP rating of IP21 is adequate for the VSD equipment.
- 14.3.3.4 The layout of the switchboard shall take into account the segregation needed for input and output power cables and control signals to limit electromagnetic interference between cables. Cable entry and exit shall be from below.
- 14.3.3.5 A maximum sound pressure level of 50 dB(A) at 1m radius is required for VSDs or their associated cooling fans which are contained within a switchboard.
- 14.3.3.6 The metal enclosure must be earthed with a maximum 0.1 Ω impedance connection to the main earthing system.

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14.3.4 Harmonics and EMC

- 14.3.4.1 All drives shall be supplied with either a DC bus choke/reactors or an AC line choke/reactors.
- 14.3.4.2 The VSD installation shall comply with local supply authority requirements. Particular reference shall be made to Energex Planning Guidelines “Harmonic Guidelines – Variable Speed Drives”.
- 14.3.4.3 The VSD shall comply with the requirements of EN 61000-6-4 (Emissions) and EN 61000-6-2 (Immunity).
- 14.3.4.4 The electrical installations Contractor shall supply, prior to installation work commencing, details of the cabling, earthing and filtering arrangements proposed in order to meet EN 61000-6-4 requirements.
- 14.3.4.5 Earthing of VSDs shall be in accordance with the manufacturer’s recommendations in order to minimise the effects of RFI.

14.3.5 Functionality for Energy Efficient, Well and Pump Cleaning VSDs

- 14.3.5.1 VSDs in [F10678](#) – Accepted Electrical Equipment List capable of the standalone functions listed in Table 3 shall be installed in preference of VSDs that cannot meet these specifications.
- 14.3.5.2 Sites that shall be considered for the installation of Energy Efficient, Well and Pump Cleaning VSDs shall meet all or some of the following criteria below:
- Pump size range is 30 kW – 70kW;
 - System head loss > 11.5m;
 - Pump age > 15 years; and
 - Blockage rate > 15 blockages / year.

Table 3 – Preferred Inbuilt VSD Control Functions

Functions	Description	Expected benefits
Efficient Speed Finder	This function shall internally calculate the specific energy of the pump, and automatically adjust the speed to optimal efficiency.	Reduced energy demand
Pump cleaning	High amp reading shall alert the SCADA system of a blockage. This initiates multiple reverse cycles until the blockage is cleared.	Reduced callouts
Sump cleaning function	Controller set to “snore” the pump once a day. This clears floating matter such as oil and grease which eventually leads to blockages.	Reduced callouts Reduced need for well cleaning
Pipe cleaning function	Pump is run to full speed at a specified interval to clear sediment in the riser pipes. This is to reduce sediment build-up.	Reduced maintenance of local network

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14.3.6 Large Sites > 60kW

Large sites are generally classified as those containing VFDs larger than 60kW. Large sites shall generally require additional sheltering and cooling. It is generally required that the switchboard shall be installed in a building. Air conditioning may be installed to maintain a well regulated switchboard temperature and extend the life of the assets. Consideration must also be given to the handling of large equipment into and out of switchboards. Wall/floor mounted VFDs within rooms shall be preferred in all instances. Alternatives to a building may be considered where the switchboard has air conditioning installed, and additional heat/elements shielding is provided in the form of a bus shelter like structure.

15. Motors

15.1. General

- 15.1.1 Each motor shall comply generally with AS 1359 and shall be suitable for connection to a three phase, 415 V, 50 Hz, multiple earthed neutral supply. The motor shall be insulated with a minimum of Class F materials in accordance with AS 2768 and shall be designed to operate within Class B limits as specified and measured by AS 1359 Part 32 specially impregnated for moist atmospheric conditions.
- 15.1.2 All motors shall be 4-pole unless otherwise specified.
- 15.1.3 Motors over 4 kW shall be protected by positive thermal co-efficient Thermistors built into the windings during manufacture in order to sense the temperature in the windings for each of the three phases.
- 15.1.4 Insulation resistance shall be guaranteed for both works test and site service conditions. Before and after the pump test at the works, the insulation resistance shall be not less than 200 MΩ. The Contractor shall guarantee the insulation resistance of the motor at the end of the defects liability period.
- 15.1.5 Electric motors intended for dry mounted indoor use shall be totally enclosed fan cooled (TEFC) with an IP rating of IP56.
- 15.1.6 Electric motors intended for outdoor use without further protection shall be totally enclosed fan cooled (TEFC) with an IP rating of IP56 with Class F insulation in accordance with AS 2768 and a Class B temperature rise as specified by AS 1359 Part 101. The motor shall be designed so that it is suitable for outdoor use.
- 15.1.7 Motors 110 kW and over shall have embedded PT100 resistors, one per phase embedded in slots in the stator. The leads for the detectors shall be wired to auxiliary terminals and clearly marked. The leads shall not be commoned on any terminal. A label shall be affixed to the terminal box clearly stating "Do Not Megger".
- 15.1.8 Electric motors greater than 75 kW and not intended for submerged operation in liquids shall be supplied complete with anti-condensation heaters fitted. Heat shall be transferred to the windings by convection. The heaters shall operate at all times whenever the electric motor is not operating. The heaters shall be rated at 240 V AC and shall be supplied and connected to separate circuits. An appropriate warning label shall be attached to the heater's terminal box stating that the heater can be live when the motor is not in use.

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- 15.1.9 Each motor shall be fitted with a stainless steel nameplate containing information as required by AS 1359 and any other applicable Standards. An additional name plate shall be supplied loose with each motor.

15.2. VSD driven motors

- 15.2.1 Motors supplied for use with VSDs shall be suitable for the application.
- 15.2.2 Where existing motors are to be connected to a VSD the Contractor shall ensure that the VSD is supplied with all necessary output filters etc. to prevent any degradation or premature failure of the motor insulation.

16. Mounting, Labelling and Identification of Equipment

16.1. Positioning and mounting

- 16.1.1 Where necessary, supports, brackets and plates for the mounting and positioning of electrical equipment such as power outlets, light fittings, switches, isolating switches, conduits, cables and the like shall be supplied and installed by the Contractor.
- 16.1.2 All supports, brackets and plates shall be 316 grade stainless steel.
- 16.1.3 Packers, shims and grouting to ensure correct levelling and alignment of equipment shall be supplied and installed by the Contractor where required.
- 16.1.4 Electrical equipment shall be mounted and positioned such that it is readily accessible for operation, inspection, replacement, modification and maintenance.
- 16.1.5 Mounting supports, brackets and plates shall be free from burrs and sharp edges.
- 16.1.6 Cutting of holes by burning methods will not be acceptable.
- 16.1.7 Electrical equipment shall be mounted on fixed structures. Where no fixed structure is available the Contractor shall supply and install a prior approved structure for the mounting of such equipment.
- 16.1.8 Mounting supports, brackets, plates and the like shall have space allowance, where required, for equipment identification.
- 16.1.9 Mounting supports, brackets, plates and the like used for the mounting of electrical equipment shall be so constructed to prevent vibration due to wind, operation and adjacent equipment or other dynamic forces.
- 16.1.10 Screws and bolts used for the mounting and fixing of electrical equipment shall be correct size and length.
- 16.1.11 Electrical equipment such as isolating switches, light switches, power outlets and the like shall be positioned and mounted 1.5m above operating floor and platform, unless otherwise approved by the contract superintendent.
- 16.1.12 Electrical equipment shall be positioned and mounted to allow bottom entry of conduits and/or cables unless otherwise detailed in this Specification.
- 16.1.13 Electrical equipment mounted along or in access ways shall be positioned such that they do not present a hazard to vehicular traffic or personnel using the access way.

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- 16.1.14 Sufficient length of UV rated waterproof flexible conduit and/or cable shall be positioned and mounted where applicable to permit the following:
- Positional adjustment of electrical equipment without electrical disconnection of it, for example adjustable flood lights, no-flow limit switches and the like;
 - Removal and/or positional adjustment on driven equipment without electrical disconnection of the motor;
 - Full motor travel adjustment must be achievable without straining or chafing conduits and/or cables or electrical disconnection of the motor.
- 16.1.15 Where equipment is mounted in pits, the pit shall be suitably drained and the equipment shall be mounted above the predicted water level. All equipment mounted in a pit shall be IP68 rated.
- 16.1.16 Where practicable, all equipment shall be mounted above Q100 levels.

16.2. Labelling and identification

- 16.2.1 The Contractor shall supply and install labels to identify all switchboards, modules and electrical components mounted on or within the respective switchboards in accordance with the equipment identification and label details on Unitywater's standard electrical drawings. Where no such identification is given, the Contractor shall seek the Superintendent's direction as to the identification to be used.
- 16.2.2 The switchboard shall be labelled with an engraved stainless steel label utilising permanent deep surface marking, black in colour. The label shall be 80 mm high and the lettering 70 mm high and 8 mm thick.
- 16.2.3 The Contractor shall attach separate 3 mm thick RWR Traffolyte labels engraved in 150 mm high letters with the pump number 1, 2 and so on for multiple pump installations to the underside of the pump well access cover with either through bolting with four 3 mm diameter 316 grade stainless steel round head metal threads or four 3 mm diameter Monel blind rivets. The heads shall be on the top of the cover. For twin pump single well installations, the pumps shall be numbered left to right when viewed from the side opposite the guide bars.
- 16.2.4 The Contractor shall attach separate 1.6 mm thick WBW Traffolyte labels engraved with 20 mm high letters with the pump number in the form "PUMP x" adjacent to each pump isolator.
- 16.2.5 Each pump shall be provided with an asset number stamped in 10 mm high letters on to a 1 mm thick 316 grade stainless steel tag permanently attached to the pump volute. The number will be supplied by the Superintendent and / or a Unitywater representative when requested by the Contractor. All test sheets and manuals shall refer to this number as well as the serial number.
- 16.2.6 The Contractor shall install the additional pump name plate supplied with the pump on the escutcheon adjacent to each pump control. Name plates shall be fixed using stainless steel screws.
- 16.2.7 The panel and equipment mounted on the switchboard shall be neatly designated by approved engraved nameplates manufactured from 1.6 mm thick WBW Traffolyte. Minimum letter height shall be 6 mm and 3 mm for major and minor labels respectively in accordance with Unitywater's standard electrical drawings.

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- 16.2.8 Labels shall be fixed adjacent to (preferably above, but not directly on) the particular item of equipment they identify, with the wording horizontal. The labels are to be fixed as close as possible to the identified item, yet not on the cable duct cover and mounted so as not to be obscured by completed wiring. Where labels are hidden, stand-off brackets or similar shall be used.
- 16.2.9 Labels shall be fixed with at least two 304 grade stainless steel screws per 120 mm label length. Screw holes shall be slightly enlarged when necessary to prevent buckling of the label.
- 16.2.10 All labels and nameplates for indoor use shall be manufactured from Traffolyte material with white lettering on red background for identification of the main switch and black lettering on white background for everything else unless specifically stated otherwise.
- 16.2.11 For outside use labels shall be engraved 316 grade stainless steel utilizing permanent deep surface marking, black in colour. Fixing shall be with stainless steel screws.
- 16.2.12 Wording on labels shall be in capital block letters.
- 16.2.13 Cable cores including neutrals shall be identified at each termination with approved full sleeve marker ferrules, numbered in accordance with the respective wiring diagrams.
- 16.2.14 Printed paper type labels will not be accepted.

17. Instrumentation

17.1. General

- 17.1.1 All instrumentation shall be installed in accordance with Unitywater's standard electrical drawings and manufacturer's instructions.
- 17.1.2 All instrumentation equipment shall comply with the Unitywater [F10678](#) – Accepted Electrical Equipment List.

17.2. Level monitoring

- 17.2.1 Level monitoring instrumentation shall consist of a hydrostatic level transmitter, a three element probe for emergency back-up and a single sensor probe for overflow detection at each pump station unless otherwise specified.
- 17.2.2 Level probes shall be positioned in the well as per Unitywater standard drawing 10-833-001.

17.3. Hydrostatic pressure transducers

- 17.3.1 Cable length shall be 15 m unless specified otherwise in the project specifications.

17.4. Single sensor probe

- 17.4.1 A single sensor probe shall be installed for overflow indication.
- 17.4.2 The probe will be suspended on its own cable and connected to a 6 mm stainless steel hook which will be hooked to a 30 mm stainless steel angle containing a polyurethane squeegee pad positioned in the opening into the wet well, so that the

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probe can be removed without entering the wet well. The squeegee will have a 30 mm hole and slot, enabling the probe to be pulled through and cleaned.

- 17.4.3 The flexible cables shall be capable of supporting the weight of the probe and cable without the need for additional support.
- 17.4.4 Probe cable length shall be sized to allow position adjustment within the well entirety.
- 17.4.5 This probe shall be installed at the surveyed RL of overflow for the station.

17.5. Three element probe

- 17.5.1 A three element probe shall be provided for the control of the emergency pump starter circuit. The probe shall be set to a well depth as shown on the standard drawing.

17.6. Flowmeters

- 17.6.1 Supplied flowmeters shall be installed mechanically according to all of the suppliers' recommendations.
- 17.6.2 The flowmeter shall be provided with earthing rings and gaskets installed in accordance with the manufacturer's recommendations.
- 17.6.3 Above ground installations of the flowmeter tubes are preferred where practical and where the site/compound is secure.
- 17.6.4 Below ground flowmeters shall be located in a drained pit with a sump well. Where gravity drainage is not feasible a sump pump complete with a liquid detection system shall be provided by the Contractor.
- 17.6.5 The Contractor shall provide a manufacturer's factory calibration certificate for the flowmeter detailing accuracy requirements are satisfied.
- 17.6.6 Flowmeters transmitters shall be supplied form 24 V DC for water sites and 240 V AC for sewage sites.
- 17.6.7 Where a flowmeter pit is to be installed the contractor shall give consideration to drainage by either gravity (preferred), or using a sump pump. The sump pump shall be connected to a GPO mounted next to the access hatch and be able to be lifted without entering the pit. Additionally all flowmeter pits shall have a minimum of 2 * 50mm conduits being for power and instrumentation.

17.7. Pressure monitoring

- 17.7.1 All pumping stations shall have provisions for discharge pressure monitoring. Monitoring points shall be brought to ground level for ease of access with isolation valves at the tapping point and connection point.

18. Telemetry and SCADA

18.1. General

- 18.3.1 Unitywater network sites shall include radio telemetry equipment as specified in the contract documentation, this Specification and Unitywater's standard electrical drawings. All equipment shall be supplied from the Unitywater [F10678](#) – Accepted Electrical Equipment List.

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18.3.2 All telemetry equipment will be mounted on a removable mounting pan in the switchboard telemetry compartment. All wiring connections from pan-mounted equipment to other areas of the switchboard will be made via a common terminal strip located on the mounting pan.

18.3.3 QR450 Radio to be mounted with sufficient space to mount ER450 (200 mmX150 mm)

18.2. Antenna requirements

18.2.1 Prior to any design work the Contractor shall engage Unitywater to conduct a radio survey. Service fees may apply. As determined by the survey results, the following will act as a guide to an acceptable antenna mounting strategy.

18.2.2 Where the telemetry unit is mounted in an external switchboard, the radio antenna shall be mounted on the vent pole as per Unitywater standard drawing U11193-2 or on a wooden pole as per Unitywater standard drawing U11193-1.

18.2.3 Where the telemetry unit is mounted inside a secure building the antenna may be mounted on the building structure. Mounting the antenna on the building structure will only be acceptable provided the antenna is a minimum of four (4) meters above ground level (or as determined by the radio survey, whichever the greater) and cannot be easily accessed by the public. Additionally, the antenna shall not be greater than 1.5 m above the bracket attachment point. If this type of installation is not possible the antenna shall be mounted on a galvanised/powder coated tapered steel pole as above.

18.2.4 A separate communications pole may be required if determined by the survey.

18.2.5 Antenna cables shall be terminated with an approved weatherproof connector and protected with a double layer application of self-fusing splicing tape with a double layer of black PVC tape.

18.2.6 The antenna must not be installed upside down; care must be taken to ensure water drains are on the bottom. The antenna must be mounted, pointing to designated Base, as per survey and be capable of rotation towards other bases.

18.3 Networking Equipment

18.3.1 All fibre to copper media converters and installation shall be Fibre 100BASE-FX, IE802.3, Multimode, SC Connectors, 9-30VDC supply voltage, DIN rail mounted, have a minimum of two copper ports, and shall be supplied preferably with a DIN rail mounted FIBOT. The copper ports shall be auto negotiating 10/100 Mbit/s

18.3.2 All unmanaged Ethernet switches shall be 9-30VDC, DIN Rail mounted, have a minimum of 2 copper ports, and be auto negotiating 10/100Mbit/s.

19. Quality Assurance, Inspection and Testing

19.1. General

19.1.1 Testing and inspections of the complete installation will include, but will not necessarily be limited, to the following:

- Inspection of switchboards, cubicles and other items fabricated from sheet metal when assembled prior to wiring;

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- FAT - Inspection and testing of completed switchboards, cubicles and other items, after completion of wiring and prior to delivery to site;
- SAT - Inspection and testing of switchboards, cubicles and other items upon completion of site installation and commissioning.

- 19.1.2 The Superintendent and/or a Unitywater Engineer reserves the right to further inspect and/or test at their expense, the whole or any portion of the articles on delivery to the site of their works. If, due to damage during delivery, offloading and stacking or due to any modification or alteration by the Contractor subsequent to any previous test, an article fails to withstand the site inspection and/or test, the article will be rejected and shall be replaced by a new article that shall fulfil all requirements of this Specification without additional charge.
- 19.1.3 Where additional visits are required by the Superintendent or their nominated representative to either the FAT or SAT due to the works not being ready to test on the initial visit, the Contractor may incur fees to cover Unitywater's associated costs.
- 19.1.4 The FAT is to use the actual RTU hardware with the relevant program loaded and will simulate all field devices. The SAT is to use the actual installed equipment and will be the testing required before commissioning commences.

19.2. Test strategy

- 19.2.1 The Contractor shall submit an Inspection and Test Plan (ITP) to the Superintendent for approval at least 4 weeks prior to commissioning.
- 19.2.2 The Contractor shall perform switchboard electrical tests and visual checks and provide completed, signed off test sheets to the Superintendent upon notification of readiness to undertake FAT.
- 19.2.3 The FAT is to be carried out in the presence of the Superintendent or their nominated representative. FAT results shall be signed off by the Contractor and Unitywater's representative upon successful completion.
- 19.2.4 The switchboard is to be delivered to site only after the successful completion of the FAT and written approval of the Superintendent.
- 19.2.5 The Contractor shall perform site installation works and carry out necessary tests prior to SAT and provide all electrical test results to the Superintendent upon notification of readiness to perform SAT.
- 19.2.6 The SAT is to be conducted in the presence of the Superintendent or their nominated representative. SAT results shall be signed off by the Contractor and Unitywater's representative upon successful completion.
- 19.2.7 SCADA commissioning shall be performed in conjunction with Unitywater's SCADA personnel.

19.3. Factory acceptance tests

- 19.3.1 A Factory Acceptance Test (FAT) shall be completed to the satisfaction of and in the presence of the Superintendent or their nominated representative before the equipment will be released for delivery to site.

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19.3.2 The Contractor shall give 48 hours notice to the Superintendent of their intention to carry out the FAT.

19.3.3 The FAT shall include as a minimum:

- Complete circuit checks of each cable, termination and circuit component against the drawings; the drawings shall be marked off accordingly and erroneous designations corrected to the satisfaction of the Unitywater representative;
- Insulation tests with 1000 V 'Megger' on all low voltage busbars, cables and equipment;
- Insulation resistance of a complete circuit shall be measured from the isolator contacts. Note – care must be exercised not to 'Megger' test sensitive equipment such as thermistors and other solid-state equipment;
- Control functionality tests of the switchboard and any associated equipment;
- Complete setting sheet for all control and protection equipment set points; this includes soft starters and VSD parameters for correct indications and logic functionality;
- Secondary current injection testing of protection circuits and operation of protective relays shall be performed.

19.4. Site acceptance tests, commissioning and inspections

19.4.1 Site Acceptance Tests (SAT) shall be undertaken prior to commissioning in the presence of the Superintendent or their nominated representative.

19.4.2 The Contractor shall give 7 days' notice of their intention to install and commission a new switchboard. The Contractor shall submit their ITP when giving notice of SAT.

19.4.3 The SAT shall include as a minimum:

- Complete circuit checks for site cabling against the drawings; these drawings shall be marked off accordingly and erroneous designations corrected to the satisfaction of the contract superintendent;
- All necessary site safety checks are performed:
 - Insulation tests;
 - Earth continuity;
 - Fault Loop Impedance tests;
 - Installations, circuits and sub mains shall be tested in accordance with AS/NZS 3000, and the Supply Authority regulations;
 - Operational sequence and interlocking checks;
 - Equipment rating checks and operational tests shall be performed including phase rotation, motor rotation, polarity, fuse ratings and overload and protection settings and operation of protection equipment;
- All control modes shall be tested including emergency back-up control mode;
- Sealing of all cables around conduits and glands shall be confirmed;
- Locks and keys are to be checked for compliance;

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- Ventilation filters shall be checked for compliance;
- Mechanical operation of doors does not foul with electrical equipment;
- Telemetry mast foundations are solid;
- Black start tests will be performed on all switchboards to ensure that all equipment will return to operating status following a power blackout without generating alarms or callouts to operators apart from power failure alarms;
- All settings, set points and software and firmware revisions are noted including level set points for all probes installed in the well;
- Generator and ATS testing where applicable.

19.4.4 The Contract Superintendent may also wish to confirm that the items tested and inspected comply with the requirements by further testing.

19.4.5 An electrical test sheet including all test values shall be completed and submitted to the Superintendent.

19.4.6 A written report including a copy of the Contractor's signed installation report shall be submitted to the Contract Superintendent, with completed Form 2.

19.4.7 Where the installation includes VSD's, the Contractor shall provide harmonics test data as per Clause 14.3.4.3 of this specification.

19.5. Testing documentation requirements

19.5.1 The Contractor shall submit an Inspection and Test Plan (ITP) to the Superintendent for approval at least 4 weeks prior to performing any Factory Acceptance Test (FAT) or Site Acceptance Test (SAT).

19.5.2 The Contractor will be supplied a copy of Unitywater's FAT/SAT Procedure for sewage pump station switchboards which shall be incorporated into the Contractor's ITP.

19.5.3 The ITP shall cover the entirety of the works and shall include as a minimum:

- Switchboard electrical tests;
- Switchboard visual checks;
- Control functionality tests;
- Equipment isolation checks;
- SCADA control and alarm tests;
- All protection and control equipment settings;
- Installation tests and checks.

19.5.4 The one test document shall be used for both FAT and SAT. The completed signed off document shall be included in the hand over documentation upon completion of the project.

19.6. Motor testing

19.6.1 All motors shall be of a type tested design. Copies of Type and Routine test certificates shall be provided if requested.

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- 19.6.2 Insulation resistance shall be guaranteed for both works tests and site service conditions. Before and after the motor test at the works, the insulation resistance shall be not less than 200 MΩ.

20. Documentation and Drawings

20.1. General

- 20.1.1 Complete manufacturing drawings shall be submitted in accordance with this specification to the Contract Superintendent for approval prior to manufacture of switchboards, disconnection boards and the like.
- 20.1.2 All drawings associated with supply and installation of electrical equipment, which will form part of the Unitywater sewerage system, shall be subject to approval from the Contract Superintendent or their nominated representative.

20.2. Drafting standards

- 20.2.1 All drawings submitted by the Contractor shall be in accordance with Unitywater's CAD Drafting Standards.

20.3. Drawing requirements

- 20.3.1 All drawings shall be produced on Unitywater's standard title block as per the drafting standards. Space has been allocated for the Contractor's details and drawing numbers.
- 20.3.2 The Contractor will be issued with Unitywater drawing numbers upon commencement of the Contract. These numbers shall be used on all drawings for the duration of the project.
- 20.3.3 The complete electrical drawing set shall include as a minimum the following:
- Site layout drawing detailing all water pipe, sewer pipe and electrical conduit runs;
 - General arrangement switchboard drawings including construction notes and equipment list;
 - Single line diagram;
 - Control schematics for all equipment;
 - RTU I/O schematics;
 - Termination diagram;
 - Auto Transfer Switch schematics where applicable;
 - Generator controller schematics where applicable;
 - Cable schedule detailing cable number, type, cross-sectional area and length of cable and gland type.
- 20.3.4 Single Line Diagrams shall include the following:
- Busbar size and capacity;
 - Circuit breaker ratings;

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- Switch and fuse ratings;
- Circuit numbers;
- Cable sizes, type and installation details.

20.3.5 The equipment list shall include details, such as:

- Manufacturer;
- Supplier, including contact details;
- Model number;
- Catalogue number;
- Quantities;
- Equipment labelling;
- Power rating (kW);
- Type and size;
- Any other information that may be required by the Contract Superintendent in identifying the item and determining its acceptability.

20.3.6 During the construction period a neatly marked set of site record drawings detailing completed works shall be maintained on site. Drawings shall be kept current with the work as it progresses and shall be subject to inspection at any time.

20.4. As Constructed drawings

20.4.1 One complete set of 'As Constructed' drawings in both AutoCAD and PDF format shall be supplied on CD/DVD. The AutoCAD version shall be as listed in Clause 20.2.1.

20.4.2 One complete set of drawings printed on A3 permanent water resistant paper is to be placed in the switchboard within an A4 plastic binder pocket.

20.5. Operation and Maintenance Manuals

20.5.1 A minimum of two Operation and Maintenance Manuals in hardcover and one electronic version on CD/DVD manuals shall be supplied covering the extent of works.

20.5.2 A draft Operation and Maintenance Manual shall be submitted to the Contract Superintendent for approval prior to the FAT. Draft manuals are required in soft copy only.

20.5.3 Information shall be collated into a single unified and indexed Operation and Maintenance Manual.

20.5.4 All electronic manuals submitted must be in a form that can be edited at a later time so that electronic manuals can be kept up to date. All documentation must be in the formats listed in **Table 4 - Document Format Requirements** below.

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Table 4 - Document Format Requirements

Document Type	Format
Text	Microsoft Word
Drawings	AutoCAD Electrical and PDF
Diagrams	Microsoft Word or Excel
Spreadsheets	Microsoft Excel
Manufacturers Manuals	PDF

- 20.5.5 The Operation and Maintenance Manual shall be in English and shall be submitted four hole-punched and bound in a stiff folder.
- 20.5.6 Content shall be specific to the particular unit described. Original content is preferred but photocopies will be accepted provided the reproduction quality and in particular the reproduction of photographs is satisfactory.
- 20.5.7 Text shall be submitted on A4 sheets. Drawings shall be A3 sized and are to be folded to A4 size in such a way that their title block is visible at the bottom right hand corner.
- 20.5.8 Operation and Maintenance Manuals shall include but not be limited to the following:
- *Cover and face sheets* - the cover and face sheets shall include the following information, suitably arranged:
 - Unitywater;
 - Name of Plant (e.g. Sewage Pump Station *ABC123*);
 - Contract number;
 - Name of equipment;
 - Date of project;
 - Titled “Operating and Maintenance Manual”;
 - Contractor’s name and address and contact phone number for service calls;
 - *Table of contents* - the table of contents shall thoroughly indicate the content and arrangement of the operation and maintenance manual;
 - *Title page* - for each item of equipment or for each grouping of similar equipment, the title page shall include the following information, suitably arranged:
 - Equipment name (and asset number if applicable);
 - Manufacturer’s name, fax number, email and web site address;
 - Equipment supplier’s name, address, email and telephone number;
 - Name plate data;
 - *Operating Instructions* - operating instructions shall include:
 - Basic theory of operation of ancillary equipment not controlled by the RTU (e.g. ATS, odour control, etc.);
 - Function of the equipment;

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- Pre-start-up checks and adjustments;
- Start-up procedures;
- Normal shut-down procedures;
- Visual checks and observations that should be made routinely to ensure equipment is operating satisfactorily;
- Diagnostic and trouble-shooting techniques, where applicable, to determine probable causes of operating difficulties or alarm situations;
- *Maintenance Instructions* - maintenance instructions shall include:
 - Recommended maintenance procedures to ensure that equipment and components are adequately maintained;
 - Frequency with which each preventative maintenance procedure should be carried out;
 - Details of any special tools, spare parts, lubricants or cleaning agents necessary to implement the preventative maintenance procedures;
 - Testing procedures;
- *Maintenance Schedule* - maintenance schedule/s detailing a complete listing of all equipment supplied and installed under the Contract; the schedule shall detail the daily, weekly, monthly and yearly maintenance of all equipment;
- *Inspection and Test Reports* - a complete copy of the FAT and SAT inspection, test and commissioning reports including those for the Supply Authority.

20.6. Asset records

- 20.6.1 The Contractor shall complete a Unitywater Asset Record sheet and return this in electronic format. The asset record sheet will be supplied by the Contract Superintendent.