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Pr9835 - Specification for Electrical Installation at Treatment Plants

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Subject Matter Expert	Infrastructure Standards Engineer Mech and Elec
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Version Review

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8.0	N/A	L. Bryson	N/A	N/A	19/05/2025 Minor admin amend to update document title for Pr10434 and STP to WWTP terminology.

Pr9835 - Specification for Electrical Installation at Treatment Plants

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1. Purpose

The purpose of this Electrical Specification is to define Unitywater requirements for manufactured electrical equipment and electrical installation works at Wastewater Treatment Plants (WWTPs) and other major treatment plants as appropriate.

The Specification defines quality, performance, reliability, durability, safety and appearance requirements for these installations.

2. Scope

This standard specification applies to all Unitywater's electrical assets located within a major treatment plant.

The scope of this specification applies to both complete and partial electrical design and installation works at Unitywater's WWTPs.

This includes, but is not limited to, the following:

- Electrical, instrument and control system design and documentation, preparation of workshop drawings, as constructed drawings, inspection and test plans, etc.
- Design, supply and installation of all electrical switchboards, control panels and local control stations.
- Supply and installation of all electrical cabling, including power, control, fibre optic, data and communication, and cable supports, including cable ladder and conduit.
- Supply and installation of all electrical equipment including test results.
- Supply and installation of PLC/SCADA and site control networking equipment.
- Electrical Hazardous Area Certification and verification documentation.

This Specification applies 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.

3. Design

3.1. Design requirements

3.1.1 General design aspects

The design shall be carried out in conjunction with the Scope of Works or the Principals Project Requirements or any other overarching document that details the specific requirements for the work.

Designs must at least address to the greatest practicable extent the following requirements:

- Safe equipment for construction, commissioning, operation, maintenance repair, removal and decommissioning activities.
- The provided equipment shall align with the Unitywater maintenance strategy for the asset class which is generally “lowest total cost of ownership”. Examples of implementing this may include: lowest maintenance cost, run to fail, lowest capital cost. The designer shall familiarise themselves with the maintenance strategy for the assets being installed to ensure the equipment provided gives Unitywater the lowest total cost of ownership.
- Maintenance and repair requirements shall be able to be carried out in the shortest possible time by Unitywater personnel unless otherwise approved by Unitywater.
- Maintenance and repair requirements must be able to be carried out with maximum available functionality of the plant and associated systems.
- Compliance with Unitywater specifications, practices and legal requirements.
- All equipment provided to Unitywater is fit for purpose and is fully maintainable for the duration of its whole life.
- Provide Unitywater with standardised, streamlined and coherent systems.
- To ensure high reliability, low maintenance and high availability systems.
- All electrical systems shall be provided with appropriate isolation facilities in line with statutory requirements, Unitywater specifications and operational requirements to assure that all electrical systems can be safely, readily and appropriately isolated and locked.
- Drawing(s) showing cable/conduit route of all underground cables as well as route of mains incomer cables. Date of first installation shall also be provided on these drawings.

3.1.2 Site, service conditions, design life aspects

All electrical equipment shall be designed to operate continuously at full load for 24 hours per day 365 days per year with a design life as outlined in **Table 1: Design Life of Equipment** below.

Table 1: Design Life of Equipment

Equipment Type	Design Life (yrs)
Switchboards, switchgear	25
Electrical Cabling	35
PLC	15
Other electronic Devices	10
Diesel Generators (standby rated)	40
Telecommunications equipment	10
Fixed radio equipment	10
Fire monitoring and reporting equipment	20
Motors (large, > 300 kW)	25
Motors (medium, >20 kW and < 300 kW)	15
Motors (small, < 20 kW)	10
Motor Protection Relay	15
Variable Speed Drives	15
Soft Starters	15
Field Instruments	15
Batteries	3

Electrical equipment shall be designed to operate in following environmental conditions and appropriate de-rating factors shall be applied:

- Coastal Environment in close proximity to the ocean
- Wet conditions
- Relative humidity up to 95 %
- Ambient temperature up to 45°C
- Cyclone Region as per AS/NZS 1170.2
- Temperature rises due to solar radiation and heat generated by the equipment itself.

Particular attention shall be paid to high corrosion resistance for all externally mounted equipment. Corrosion resistance and protection shall ensure the life expectancies listed in **Table 1: Design Life of Equipment** are achieved or bettered.

All main switchboards and all motor control centres shall be installed inside enclosed buildings/switchrooms.

Distribution boards shall generally be installed within enclosed buildings/switchrooms.

Switchrooms shall be air conditioned under normal operations. However, in the event of failure of the air conditioning system, all equipment within switchrooms shall be capable of continued operation at the maximum expected ambient temperature and relative humidity.

Air conditioning systems within switchrooms shall be designed such that if one unit fails the remaining units can maintain ambient temperature to the range of 25-30°C.

All WWTPs shall have backup generating sets capable of supplying the load for the entire site for periods of time when there are power outages. The generating set(s) shall be connected to an ATS and shall automatically switch from main supply to backup supply when there is a power outage. The power supply shall switch back to mains supply once power has been restored.

Equipment shall be rated to at least 60°C.

Equipment must not be located beneath overhead powerlines. Where equipment/sites have nearby overhead powerlines, care shall be taken to locate equipment a minimum of 3m in the vertical plane outside of the powerline corridor.

All switchboard equipment and other critical electrical equipment shall be mounted at least 300mm above Q100 flood levels.

3.1.3 Equipment and fault coordination

The design shall ensure that every item of equipment is suitable for operation at the required fault level or is protected by upstream fault limiting or coordinating devices.

Protective equipment shall be fully coordinated so that no item is called upon to break fault current in excess of its fault rating. This shall include control circuit breakers if single phase control is used. Control circuit shall be fault limited to less than 5 kA.

Power and control cable protection shall be such that the energy let through by the protective device does not exceed the level permitted for that cable by AS/NZS 3008.1.1.

If fault limiting devices or coordinated circuit breakers are used, then these shall be fully rated for the fault level specified.

Equipment coordination shall satisfy the requirements of Type 2 coordination between circuit breakers, contactors and backup protection of circuit breakers.

3.1.4 Design for safety

Systems shall be designed and constructed as far as practicable to protect against foreseeable misuse and damage to the facilities and equipment and to extend the safe operation and maintenance of the installations over the duration of the nominated asset life without need of rehabilitation.

Due consideration shall be made in the design of the equipment to simplify installation and termination of field cables.

All necessary safety facilities and mechanisms shall be installed to assure that there are no exposed live conductors when any switchboard door is open. This is to prevent accidental contact with otherwise exposed live circuits behind doors or hinged panels that may be opened without special tools and also when specifically directed within the Scope of Works or the Principals Project Requirements or any other overarching document that details the specific requirements for the work.

Any hazardous materials used in the design and construction of equipment shall be submitted to Unitywater for approval prior to the items being used.

Where hazardous areas have been identified, the detailed design, installation and testing of the hazardous area installation shall be in accordance with AS/NZS 60079 and AS1375.

Particular attention shall be paid to switchboard equipment or other large/heavy items (cables etc) that may require manual handling in the future because of failure. Consideration may need to be given for externally mounting some equipment to achieve a safe design.

When installed, the doors of any cabinet must open away from site wells/pits. Equipment must be mounted in such a way that there are no hazards within 1500mm of the equipment when performing regular/routine tasks e.g. roads, wells, pits, trip hazards etc.

3.1.5 Preferred equipment and standardisation

All equipment shall comply with Unitywater's F10678 - Accepted Electrical Equipment List. Where items of electrical equipment to be supplied are not detailed on the equipment list they shall meet the requirements of this specification and shall require the acceptance of Unitywater's Infrastructure Standards Team prior to installation of such equipment.

All items of equipment having equal or similar functions shall be of the one manufacturer and of similar appearance, finish, mounting arrangement and the like.

Where alternatives of equipment are permitted under this Specification and more than one item is to be supplied, all equipment shall be of the same manufacturer and type.

Existing equipment on plants shall be considered when new equipment is installed to ensure standardisation, however new designs should generally follow the latest Unitywater requirements where practical. Approval from Unitywater's Infrastructure Standards Team is required when standardising to existing plant where it does not meet current requirements.

Designs must be carried out a far as practicable using Unitywater's standard electrical drawings. Where a standard drawing does not exist for the specific purpose then the Unitywater Infrastructure Standards Team must be consulted to provide direction.

3.1.6 Access to equipment

All equipment shall be located and installed so that it will be readily and safely accessible for operation and maintenance.

The equipment layout shall provide adequate access for operation with all indicators and instrumentation in easy to read locations.

Equipment mounted in or above large open vessels (e.g. Clarifier, MBR, etc.) shall be easily and safely accessible without the need for additional equipment.

All electrical and instrumentation equipment shall be located to allow unobstructed, easy and safe access for maintenance, removal and replacement of items. Operator interfaces shall be mounted between 1000 mm and 1600 mm above working floor height and junction boxes shall be mounted between 500 mm and 1600 mm above working floor height.

Equipment shall be mounted such that it does not obstruct or impede walkways, platforms and other normal areas of access as required by applicable statutes and specifications.

Under no circumstances is a design/site layout acceptable that necessitates use of scaffolding or ladders to access any electrical equipment, panels etc. for maintenance or operations once installation is complete.

3.1.7 Design review and verification of design

The Designer is responsible for providing a design that meets or exceeds the requirements of this specification and other relevant standards.

Unitywater will carry out a design review for general compliance with this specification and relevant Australian Standards. A Unitywater review does not imply the design meets all of the requirements of this specification or relevant standards.

All designs shall be design checked or verified.

The design check or verification shall be undertaken by a professional engineer who has RPEQ Registration from the Board of Professional Engineers Queensland, in the category appropriate to the item being design checked or verified.

The following minimum calculations shall be provided as part of the design (note that some of these are standard outputs from reporting requirements to meet Pr10618 - Specification for Power Systems Analysis and Arc Flash Studies):

- 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, sub mains and field equipment
- Switchboard fault current level
- Protection Coordination and Discrimination
- Arc flash PPE category.

3.1.8 Environmental design aspects

All designs, plant and equipment shall be arranged and implemented as far as practicable to achieve the following:

- Ensuring that regulatory requirements to which Unitywater is obligated to comply with are complied with sustainably.
- Ensuring that life cycle management aspects and related environmental consequences can be sustainably addressed.
- Contributing to carbon footprint and energy cost minimisation.

3.1.9 Corrosion protection

All equipment and fixings shall be selected so that it is suitable for the corrosive effect of the environment in which it is installed. The equipment shall provide a service life of at least the periods nominated **Table 1: Design Life of Equipment** without excessive maintenance.

Where dissimilar metals are installed in close proximity to one another, care shall be exercised to avoid the effects of galvanic corrosion. The components shall be:

- Made from compatible material either inherently sealed from the environment, e.g. stainless steel, or
- Electrically isolated from each other by separation using either:
  - a minimum 3 mm air gap, or
  - a minimum 2 mm of UV resistant, non - hygroscopic material such as rubber, PVC or polythene, or
  - interstitial spacer.

Welding of corrosion-protected surfaces shall not be allowed unless specifically permitted.

Stainless steel components shall be thoroughly passivated after welding or being subject to any process that creates an oxide layer.

3.1.10 Provision for handling equipment

All heavy equipment items supplied to Unitywater shall have provision for lifting, slinging and handling during installation and overhaul or maintenance.

All parts normally lifted during periods of maintenance and weighing one tonne or over shall be marked with their weight.

Certified Eyebolts and lifting points shall be provided where necessary to facilitate handling and overhaul of the various parts of the equipment.

3.2. Electrical supply and power distribution

3.2.1 Power source

The electrical supply to the installation shall be as detailed in **Table 2: Electrical Supply Requirements** below.

Table 2: Electrical Supply Requirements

Electrical Supply Aspect	Requirement
System Voltage	400V +10%, -6%
Phases	3 phase and neutral (4 wire)
Frequency	50Hz ±1%
A-Phase B-Phase C-Phase Neutral Earth	Red White Blue Black Green/Yellow

The site supply parameters, any specific quality requirements for the site and the maximum demand requirements for the site shall be confirmed with the local supply authority prior to design of the electrical works.

The preference for phase sequence at the incoming terminals of the main switchboard is clockwise. Where the incoming phase sequence is not clockwise, then it is acceptable to transpose incoming phases. For existing sites the phase sequence may not be clockwise and does not need to change unless a significant project has the ability to change the phase sequence.

The same phase sequence as provided by the local supply authority to sub-mains, switchboards and multi-phase loads shall be adhered to throughout the installation.

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/NZS 3008. Where a site has a known upgrade path or future development, then the consumer mains need to be sized according to the known future load if this is warranted.

3.2.2 Voltages

The Unitywater standard voltages shall be as outlined in

Table 3: Standard Voltages below.

Table 3: Standard Voltages

Equipment	Voltage
Main Plant Switchboard	400 V AC, 3 Phase + Neutral + Earth. Solidly earthed neutral (MEN system).
Diesel Generating sets	400 V AC, 3 Phase + Neutral + Earth. Solidly earthed via LV switchboard. Use MEN at main switchboard.
Motor Control Centres (MCC)	400 V AC, 3 Phase + Neutral + Earth. Solidly earthed via main switchboard., (MEN system only if main switchboard.)
Lighting and Small Power	400/230 V AC, 3 Phase/single phase.
Motor Contactor Coils	Regulated 24V DC. Positive & Negative
General Control Circuits (including motors, ACB, lighting etc)	Regulated 24V DC. Positive & Negative
Field Instrument Power Supply	Regulated 24 V DC. Negative connected to instrument earth system.
Field Control devices and control circuitry external to LV switchboard and control panels	Regulated 24V DC. Positive & Negative
Control valves – non-24VDc instruments	400/230 V AC, 3 Phase/single phase.
Telemetry system, radio equipment and other communications equipment	Regulated 24V DC. Positive & Negative
Control Circuits for Safety Systems	Regulated 24V DC. Positive & Negative

3.2.3 Power supply quality

The design shall comply with the local supply authority power quality requirements.

The power supply quality requirements shall include voltage disturbance (fluctuations), voltage distortion (harmonics), power factor, negative phase sequence (unbalance) and any other requirements of the local supply authority.

The equipment shall be capable of continuous satisfactory operation with normal voltage variations and frequency variations as outlined in **Table 2: Electrical Supply Requirements** above.

All low voltage switchgear and control equipment shall operate satisfactorily for voltage drops up to 5% of nominal voltage during normal running conditions and up to 15% of nominal voltage during motor starting.

Electronic circuitry shall be adequately rated and fitted with voltage and current surge protection and have immunity from Radio Frequency Interference (RFI).

3.2.4 Power system protection

The minimum protection functions of the power system are as shown below in **Table 4: Minimum Protection Functions**.

Table 4: Minimum Protection Functions

Equipment	Protection
Diesel Generating set CB	Over Current Short circuit Earth fault Over and under frequency Over and under voltage
Switchboard Incoming CB	Over current Short circuit Earth fault Supply Authority requirements for sites that synchronise

3.2.5 Power supply metering and power monitoring

Metering requirements are to comply with the Queensland Electricity Metering Manual (QEMM) and Queensland Electricity Connection Manual (QECM).

All sites will require CT metering.

Equipment for CT metering may include:

- Load Break Isolator (rated to the incomer rating)
- Current Transformer (CT) supplied/specified by local supply authority
- Power meter (electronic, three phase)
- Test links, fuses and connections.

Buildings for switchboard for the site must be dedicated switchrooms and are not to be used to house other equipment.

The metering panel shall be installed in a location in accordance with local supply authority requirements.

For main switchboards it is preferred that an external metering panel should be provided such that the local supply authority does not need to enter any Unitywater buildings.

Power monitoring is required on all three phase switchboards except for general light and power.

A three pole suitably sized circuit breaker must be used to isolate the line side of the meter.

Shorting and/or isolation links must be provided for CTs.

3.2.6 Equipment isolation

Full current load break isolation shall be provided at the point of electrical supply to individual electrical equipment and motors i.e. within the switchboard/MCC. The isolator or circuit breaker shall be pad-lockable in the 'off' position.

Isolators shall have a minimum duty rating of AC23 and shall be capable of breaking the full locked motor current of the motor or the maximum surge current of other equipment.

Where barriers and shrouding are fitted they shall have "Danger xxx Volts" labels fitted where xxx is the supply voltage.

All electric motors shall also have a full current load break isolator near the motor for maintenance and isolation purposes. This shall be installed as an integral component of the LCS (refer Section 11.3 for details of LCS) and shall be able to be locked with a padlock.

All full current load break isolators shall have provision for auxiliary contacts for input into the control system and the control circuit.

3.2.7 Power recovery

After a power outage all equipment shall return to its previous state prior to the power outage including all operational plant and ancillary equipment. On loss of mains supply an automated changeover of power to the permanently installed generator shall be provided. A time delay may be incorporated to ensure the generator is needed.

When power is restored from a Supply Authority power outage there shall be a seamless transfer from generator supply to mains supply. In this context, seamless transfer is taken to mean no interruption to power supply, i.e. synchronisation with the Supply Authority and a controlled transfer of load to mains supply.

Where seamless transfer of load from generator to mains supply cannot be achieved, the plant control system will have a shutdown and start up sequence to minimise the impact to plant operation.

All equipment shall return to its normal operating state when planned switching to generator supply occurs and when switching from generator back to main supply. Particular attention shall be paid to MVAC system and fire protection systems within buildings.

3.3. Switchrooms

3.3.1 General design requirements

Switchrooms shall be use for electrical equipment installation only. Switchrooms are not to be used for storage.

Switchrooms with air conditioning must be appropriately insulated to ensure economical use of cooling is achieved.

3.3.2 Construction

Switchrooms may be block buildings as per Pr9902 or a transportable building.

The switchroom must accommodate all electrical switchboards, distribution boards, control system panels, VFD, UPS racks, communications racks and any other ancillary electrical equipment required for the operation of the plant.

All building services must be contained within the walls/cavities. This includes but is not limited to general light and power, communication, security and control system cabling. Surface mounted conduits are not preferred.

3.4. Switchboards – design

3.3.1 General design requirements

Switchboards shall be designed with the following considerations:

- Location of switchboard within switchroom
- Maximum length of the switchboard
- Maximum Height of the switchboard
- Availability of space at installation location (existing sites)
- Purpose of the switchboard – Main Switchboard, Motor control, distribution board, etc
- Short circuit withstand capability
- Protection of persons against electric shock
- Maintenance and upgrade capability
- Current carrying capacity
- Form factor
- Arc flash risk mitigation (if applicable).

3.3.2 Compliance requirements

Switchboard design and construction shall comply with the requirements of AS/NZS 3000 and the relevant parts of AS/NZS 61439. These standards define the minimum requirements acceptable. This specification or other Unitywater requirements may stipulate higher standards.

Switchboard design shall at a minimum meet **Table 5: Switchboard Application and Compliance Requirements**.

Table 5: Switchboard Application and Compliance Requirements

Switchboard Rating/Purpose	Minimum Compliance Requirements	Minimum Fault Rating
Single Phase Switchboard/Distribution Board	AS/NZS 61439-3	As per AS/NZS 3000
Three Phase Light and Power Distribution Boards or other General Distribution	AS/NZS 61439-3	10 kA, 0.1 second or as per AS/NZS 3000
Three Phase Switchboards less than 250A	AS/NZS 61439-1	10 kA, 0.1 second or as per AS/NZS 3000
Three phase Switchboards 250A or more but less than 400 A	AS/NZS 61439-1	20 kA, 1 second
Three phase Switchboards 400 A or above	AS/NZS 61439-1 with tests from Appendix ZD	40 kA, 1 second

Electrical equipment shall have a fault rating greater than the fault level at the installation location.

The internal separation of the switchboard shall be considered with the safety of operational and maintenance personnel to be the highest priority.

Internal separation shall be in accordance with AS/NZS 61439.1.

3.3.3 Location

Switchboards housed within a building shall have a minimum enclosure rating of IP54 as per AS/NZS 61439.

Where external switchboards have been allowed, they shall have a minimum enclosure rating of IP56 as per AS/NZS 61439.

The internal temperature of the switchboard must not exceed 35°C under normal operation. Heat loading calculations may be required to ensure this condition is met because of environmental factors or electrical equipment installed within the switchboard. Examples of how to ensure compliance with this requirement include but are not limited to the following:

- Air Conditioned buildings
- Switchboard vents
- Forced cooling
- Relocating equipment
- Shade sheds or sun shields (external switchboards only).

Switchboards/control panels must not be installed within bunded areas or hazardous area e.g. chemical dosing, to ensure emergency egress and longevity of electrical devices is maintained.

3.3.4 Future expansion

New switchboards shall be designed and installed with a minimum of 20 % spare space capacity and 25% spare load capacity; this may be increased depending upon location and future services to be connected. Spare capacity beyond these requirements shall be further outlined in the project requirements.

3.3.5 Loads

It is preferable to have a Main Switchboard that feeds individual large loads and multiple MCCs for a site. Some sites may have a combined main switchboard/Motor Control.

In general, the switchboard will house variable speed drives, motor protection relays, control circuitry and communication devices.

Small variable speed drives shall be installed internally to the switchboard unless stated in the project requirements.

Large variable speed drives shall be installed externally to the switchboard unless stated in the project requirements.

Other large items not mentioned above that would be difficult to remove or replace shall be mounted externally to the switchboard unless stated in the project requirements.

All control circuitry for a drive shall be contained in the functional unit and shall not be separated or distributed.

Consideration is to be given to replacement of functional units and bus bar connected isolators in terms of safe removal and replacement of these items. A bus tie may be required in certain installations to maintain plant operability while these activities are carried out. If multiple MCCs are installed in the same switchroom, consideration must be given to distributing the same equipment, i.e. Pump 1 in MCC1 and Pump 2 in MCC2. This clause also applies if the Main Switchboard is a combined Main Switchboard/MCC.

3.3.6 Dimensions and provision for handling

The switchboard shall be designed to fit appropriately in the space allocated. In certain installations there may be a restriction on switchboard length to suit the switchroom.

The maximum height of any switchboard is to be considered during the design.

In certain installations the height may be restricted due to existing infrastructure.

The switchboard is to be designed with transportation requirements considered, in particular transportable sections.

The maximum length of any section shall be no more than 2700 mm.

Sufficient eye bolts shall be fitted for lifting with covers installed over holes after installation

3.3.7 Arc flash risk mitigation

As part of the switchboard design the results from the Power System Analysis (refer Pr10618 - Specification for Power Systems Analysis and Arc Flash Studies) need to be considered and may impact the switchboard design. The electrical design and the power system design need to be complemented by the switchboard design.

The incident energy must be reduced as far as practicable, however design must not inhibit defined operational requirements.

Table 6: Arc Flash Risk Design Requirements below details the considerations for arc flash design requirements dependent upon incident energy results.

Table 6: Arc Flash Risk Design Requirements

Incident Energy	Design Requirements
Less than 1.1Cal/cm^2	No additional requirements
Greater than 1.1Cal/cm^2 but less than 7.5 Cal/cm^2	• Consideration of additional separation requirements of conductors or arc fault contained enclosure to AS/NZS 61439. • Consideration to be given to remote switching of devices. • Other ways to reduce the incident energy or safety mechanisms to improve operational safety.
Greater than 7.5 Cal/cm2	• Verified arc fault contained enclosure to AS/NZS 61439 Appendix ZD tests. Special Tests as detailed in ZD6 are preferred however not mandatory for Unitywater's acceptance. • Remote operation of all devices that are impacted i.e. isolator and circuit breaker. • Consider alternative protection devices.

3.3.8 General arrangement

The switchboard shall be laid out in a logical manner with construction, operability and maintainability the primary design drivers.

The switchboard builder shall be responsible for the detailed design of the switchboard.

Motor control centres shall be supplied with vertical cable zones adjacent to each tier and with a horizontal wiring enclosure running along the top of the tiers for the length of the board.

Where possible, cable zones should not be shared for duty and standby equipment,

All switchboards, MCC, control panels or any other electrical equipment shall be bottom cable entry only. Any other point of entry that is not the bottom of the switchboard requires the approval of Unitywater Electrical Engineering personnel.

3.5. Earthing - design

Earthing design and installation shall comply with the recommendations, regulations and requirements set out in AS/NZS 3000, the Electrical Supply Authority and relevant Acts and Regulations.

Where necessary, a site survey shall be carried out to determine soil resistivity and hence the optimum type, quantity and arrangement of earth electrodes in order to achieve the required resistance, together with any grading electrodes needed to control potential radiant for the installation. These requirements shall be incorporated, as required, into the civil/structural design.

The main earth rod shall be installed in an earth pit.

The earth bar within each switchboard shall be provided with minimum 20% spare (unused) connections.

The neutral bar within each switchboard shall be provided with minimum 20% spare (unused) connections and shall be fully labelled at each termination.

The M.E.N. link shall be provided in the main switchboard only for the site.

Neutral and earth busbars shall be completely isolated from each other, except for the M.E.N. link.

A separate drawing may be required to detail the earthing design.

Main earthing conductors shall be provided from the main switchboard, main earth bar to steelwork, incoming services, etc., in accordance with AS/NZS 3000 and to the following:

- Main earth electrode installation
- Motor control centre earth bars (if applicable)
- Mechanical equipment
- Earth Test Points.

No earthing system shall rely upon the metalwork of plant or equipment for earth continuity.

Calculations for earthing shall be provided to Unitywater to ensure compliance with AS/NZS 3000.

All doors for switchboards, MCC, Control panels, panels, LCSs shall be effectively earthed to the case by means of flexible connection not less than 4 mm² to a door stud.

Hinged joints (e.g. doors, escutcheons, hinged panels and removable panels) whether carrying wiring or not shall be provided with flexible earth bonding strap of adequate size.

The gland plate (if applicable) for all switchboards, MCC, Control panels, panels, LCSs shall be effectively earthed to the case.

Cable ladder routes shall be bonded to the plant earth.

3.5.1 Earth test points

Earth Test Points shall be strategically placed throughout the site to reduce risk when performing future maintenance testing activities. Considerations when choosing locations for Earth test points include but are not limited to the following:

- where there is a large amount of electrical equipment in an area
- where electrical equipment is installed across one or more roads from where the switchboard earth is.

Each earth test point must be a hardwired earth cable from the main earth bar.

Each earth test point must be able to be easily removed/disconnected for testing purposes.

Each earth test point must be isolated/insulated from the main earth installation to prevent earth loop issues.

Earth test points must not be used as protective earths.

Cabling for earth test points must be a minimum of 10mm^2.

3.6. Control system

Section reserved for future use.

3.7. Instrumentation

Section reserved for future use.

3.8. Motor starters

Section reserved for future use.

3.9. Field equipment

Section reserved for future use.

3.10. UPS

Section reserved for future use.

3.11. General light and power

All designs shall give due consideration to light and power distribution. Design lighting levels are defined in Table 14: Luminance Levels.

General purpose outlets shall be installed in logical and accessible locations.

Lighting design shall take into consideration location of lights and be designed to ensure ease of maintenance.

The lighting design for external parts of the plant must be considered holistically from a site level and not just for specific areas.

4. Switchboards and Motor Control Centres Construction

4.1. General requirements

The following switchboard functions and requirements are defined elsewhere:

- Distribution Boards (details provided in Section 4.7)
- Control Panels (details provided in Section 11.5)
- Local Control Station/Disconnect Box (details provided in Section 11.3).

The switchboard builder shall be responsible for the detailed design of the switchboard.

Switchboard rating and specific requirements are detailed in Table 5: Switchboard Application and Compliance Requirements in Section 3.3. This section pertains to applications associated with:

- Main switchboard
- Motor Control.

Spare space shall be provided in the switchboard as detailed in section 3.3.4 with total space allocated to starter and supply equipment/modules and excluding cable zones. This is to be detailed on the general arrangement drawings.

This space shall be placed preferably at one end of the switchboard and provision for future expansion shall be allowed from this end of the switchboard to facilitate expansion; a removable blanking plate shall be installed over the end of the busbar chamber and cable zone.

Where a switchboard builder has carried out testing/verification to meet the requirements of AS/NZS 61439, then the verified design switchboard shall be provided and compliance with parts of Section 4.2, 4.3, 4.4 and 4.9 may not be able to be met. The switchboard builder must provide details of where their design differs from that specified in nominated sections.

Equipment ratings developed during the design shall be shown on the drawings and shall be the required ratings after all de-rating factors have been applied.

The full load rating for motor circuits shall be taken as the motor full load current while the rating for other circuits shall be the circuit breaker rating.

4.2. Arc fault containment performance

Where the results of the Power System Analysis as per Pr10618 **-** Specification for Power Systems Analysis and Arc Flash Studies indicate the incident energy at any point within the switchboard is greater than 7.5Cal/cm^2 the affected compartments must comply with the requirement in Section 3.3.2 above and be arc fault contained to AS61439.

If the fault level nominated is greater than 30kA for 1 second, then the switchboard supplied shall be of the arc containment type.

Arc containment switchboards, including motor starting and feeder equipment shall provide ‘acceptable protection' for operators in the event of an internal arcing fault occurring on the load side of a protective device in any switchboard compartment. For design arc flash risk mitigation requirements see Section 3.3.7.

The verified design being offered shall have testing certificates in accordance with AS/NZS 61439.1 by a recognised testing authority. Arc Fault containment shall be in accordance with Annex ZC and ZD of AS/NZS 61439.1 and as per requirements of Section 3.3.

The construction methods used in the tested switchboard (e.g. venting, door bracing and door mounted equipment shrouding) shall be the same as in the switchboard being supplied.

The protective devices (circuit breakers and fuses) shall preferably be the same as those tested although not every protective device rating need have been tested.

4.3. Switchboard construction

4.3.1 External switchboards

Where external switchboards are allowed, the following requirements must be met.

The switchboard shall be a completely self-supporting fully welded rigid structure, constructed from formed Marine Grade Aluminium 5251 or 5083, of minimum thickness 3.0 mm or 1.6 mm Stainless Steel 316 folded and seam welded, free from corrosion, dents and any surface defects.

Where panels are manufactured using aluminium the equipment mounting panels shall be a minimum 2.0 mm thick for those panels up to an area of 500 mm x 500 mm. Where panels are larger, 3.0 mm thick mounting plates shall be used, supported by studs of adequate size welded to the case. Large equipment mounting panels, (exceeding 1000 mm in any direction) shall be secured by a minimum of six welded studs and nuts.

No equipment is to be mounted outside of the switchboard besides necessary labelling. Equipment shall instead be mounted on or behind an escutcheon.

Sunhoods and sun shields shall be fitted to the top, front, back, unless a particular surface of the switchboard is not affected by the sun e.g. up against a fence where the rear heat shield may not be required.

Sun shields are to be bolted to studs welded to the main panel using stainless steel button head socket bolts.

Sun shields are to have folded edges and corners bevelled. They must not pose a risk of injury.

Sunhoods shall extend 600mm from the front edge of the switchboard to provide protection from the sun and rain.

Where vent cowls are provided for heat dissipation or for any other reason, the switchboard builder must provide certification that the switchboard maintains the requirements of AS61439 especially in regards to IP rating.

Where vents are required for cooling, they shall be directed away from where personnel would stand during normal operations. Vents are not be placed in escutcheon doors.

Where heavy equipment has been approved for installation in an external switchboard the heavy equipment shall be supported by separate independent framework and shall not rely on the enclosure sheeting. Permanent apparatus must also be provided to allow the heavy equipment to be removed if it fails e.g. sliding rails/shelf, Installation of heavy equipment within an external switchboard must have approval from Unitywater Engineering personnel after a full safety in design risk review has been carried out.

All nuts, bolts and studs shall be 316 Stainless Steel.

Where an assembly is to be installed over a trench or open floor, adequate access for installation and future maintenance of cabling including trench cover plates shall be provided.

4.3.2 Internal switchboards

The switchboard shall be a completely self-supporting fully welded rigid structure, constructed from formed Marine Grade Aluminium 5251 or 5083, of minimum thickness 3.0 mm or 1.6 mm Stainless Steel 316 folded and seam welded, free from corrosion, dents and any surface defects. Zinc Anneal, powder coated switchboards of minimum 2.0 mm thickness will only be considered where the switchboard is installed within a sealed air conditioned switchroom and by agreement with Unitywater.

Equipment mounting panels shall be a minimum 2.0 mm thick for those panels up to an area of 500 mm x 500 mm. Where panels are larger, 3.0 mm thick mounting plates shall be used, supported by studs of adequate size welded to the case. Large equipment mounting panels, (exceeding 1000 mm in any direction) shall be secured by a minimum of six welded studs and nuts.

Heavy equipment shall be supported by separate independent framework and shall not rely on the enclosure sheeting. All nuts, bolts and studs shall be 316 Stainless Steel.

Where an assembly is to be installed over a trench or open floor, adequate access for installation and future maintenance of cabling including trench cover plates shall be provided.

Floor mounted assemblies installed in rooms with suspended floors or over open cable trenches shall be provided with an additional supporting framework suitably fixed to support the assembly's bed frame or plinth.

4.3.3 Doors

Doors shall be constructed from the same material as the switchboard and shall free from corrosion, dents and any surface defects.

All doors shall be fitted with stainless steel door stays to hold the doors open at a minimum 105 degrees.

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.

Doors shall sealed to exclude water and dust to meet the IP rating required. Door seals shall be protected from direct sunlight.

Unless differences are required as part of a switchboard design to meet AS/NZS 61439, hinges shall be lift-off type chrome plated solid brass body (80 mm minimum length) with stainless steel hinge pins.

Doors shall not be wider than 900mm.

Doors over 1200mm in height shall have a minimum of three (3) hinges.

Stiffeners shall be fitted to all doors with dimensions in excess of 1000 mm high and 450 mm wide, or as required.

Unless differences are required as part of a switchboard design to meet AS/NZS 61439, all doors for internal switchboard shall be fitted with chrome plated quarter turn locks with 8 mm solid square insert.

All doors for incomers, ATS, Supply Authority metering, generator feeders and power feeders shall be held closed with 316 stainless steel SelectLok semi flush type padlockable swing handles.

Doors shall be 3-way latching if over 1000 mm in height.

Doors for vertical cable zones shall have pintle hinges and be secured with 316 stainless steel 8mm solid square latches.

Sufficient space shall be allowed for all doors to open fully without fouling other items of equipment or other open doors.

All doors shall have flexible earth straps to the switchboard frame.

4.3.4 Escutcheons

Escutcheons shall be constructed from the same material as the switchboard and be free from dents and any surface defects, powder coated gloss white. They shall be hinged and removable in the fully open position.

Hinges shall be of the concealed or chrome plated type solid brass body (80mm minimum length) with stainless steel hinge pins.

Unless differences are required as part of a switchboard design to meet AS/NZS 61439, all escutcheons shall be fitted with chrome plated quarter turn locks with 8 mm solid square insert.

Escutcheons over 1000mm in height shall have a minimum of three (3) hinges.

All escutcheons, hinged panels and removable panels shall have flexible earth straps to the switchboard frame.

4.3.5 Equipment mounting

No piece of equipment which is to be operated or viewed by an operator (pushbuttons, switches, and meters) shall be mounted more than 1900 mm or less than 400 mm above finished floor level.

Opening any door or removing any cover must not be required for operation or resetting any piece of equipment.

No piece of equipment shall be mounted behind other equipment or in any manner denying free access for removal or maintenance.

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.

All equipment within modules shall be mounted on removable equipment panels. Equipment mounted on equipment panels shall be fixed by means of stainless steel metal thread screws and tapped holes or DIN rail mounting.

Self tapped fixings shall not be used. Equipment within small modules (less than 250 mm high opening) shall be mounted within 200 mm of the front of the MCC to allow better access to terminals.

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.

All DIN rail shall be aluminium or stainless steel.

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, such as Anti-Seize or similar, shall be used.

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.

Items of equipment or terminals shall be no closer than 300 mm measured vertically from outgoing gland plates.

All equipment and devices shall be installed in such a manner that all necessary electrical clearances are observed and that the rating accuracy of devices is not impaired either thermally or electro-magnetically by the proximity of other devices or cables.

All live parts (including terminal, fuses, busbars, and control devices and meters mounted on switchboard doors) which are behind hinged, noninterlocking doors or escutcheons and which carry a voltage greater than 25V AC or 60V DC 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.

4.3.6 Covers

Covers shall be constructed from the same material as the switchboard and be free from corrosion, dents and any surface defects.

All covers shall be secured using 316 stainless steel acorn nuts. A minimum of six are required if the cover is over 1000 mm in any direction.

Acorn nuts shall only be used for covers for busbar zones and horizontal cable zones and the top and bottom of switchboards.

4.3.7 Switchboard compartments

4.3.7.1 General

A clear space of at least 1000 mm in front of the assembly shall be provided.

Sufficient clear space above a panel shall as far as practicable be provided to allow access for installation repair and maintenance and for a bus-bar constructed panel shall be of nominal distance 600 mm.

4.3.7.2 Metering

Main switchboards shall provide a compartment for Supply Authority metering equipment, noting the requirements of Section 3.2.5 Power metering and monitoring.

4.3.7.3 Motor starters

Switchboard Compartments shall have standardised width and depth and an interchangeable standardised set of heights.

Compartments shall be designed and sized for ease of access for maintenance.

Module doors covering low voltage equipment shall have defeatable door interlocks. The interlocking switch shall be padlockable in the off position. Control circuit shall be housed in fully sealed compartments.

VSDs and other large equipment are to be mounted external to the switchboard. As such, all control circuitry should be routed through the relevant switchboard compartment.

4.3.7.4 General distribution

A compartment/cell may be supplied for general distribution. General power distribution may be achieved by din rail mounted circuit breakers or if greater than 18 poles are required then a chassis type distribution is to be installed.

Larger switchboards will achieve general distribution by busbars to individual compartments or as per the switchboard builders design.

4.3.7.5 Control System and/or Control (ELV)

Control system and communications equipment shall be located and installed in a separate compartment from the switchgear and control gear. The compartment shall be suitably sized to accommodate the required hardware and connection terminals.

The control system compartment(s) shall have the following equipment installed:

- a 24 VDC power supply
- PLC equipment
- Fold Down laptop table on the inside of the door.

The enclosure shall be lit by a minimum of a 240 lux lamp to provide acceptable illumination level for detailed work. Irrespective of this requirement the minimum illumination levels shall be complied with as per Section 12.7.

The Plant Control System shall have a dedicated marshalling terminals strip located in the cubicle.

Each individual input or output (I/O) of all installed I/O cards shall be wired to the marshalling terminal strip including those I/O designated as “spare”.

All equipment and circuits shall be IP2X rated.

Miniature circuit breakers and any other equipment used in DC applications must be rated appropriately.

4.3.7.6 Cable zones

Unless otherwise specified by standard drawings, switchboards shall be supplied with vertical cable zones adjacent to each tier and with a horizontal wiring enclosure running along the length of the switchboard.

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

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.

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

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.

All cable entries shall be effected using glands.

4.3.8 Sealing

All switches, control devices or instruments protruding from a panel shall be sealed to match switchboard degree of protection or mounted behind a sealed perspex window in the panel to achieve higher rating.

Switchboard modules shall be sealed to restrict arc transmission in the event of a fault.

Each phase of the connections between the busbars and the line side of functional unit protective devices shall be individually supported and sealed to achieve better sealing i.e. the three phases shall not be brought through the same hole into the module.

Provision shall be made for sealing switchboard modules after the installation of field cabling. All cable entries should be via IP rated glands to ensure IP rating is maintained.

Module cable entry points shall be bushed to prevent cable damage.

4.3.9 Shrouding

All live parts (including terminals, busbars, conductors, batteries and control devices and meters mounted on the doors) which are behind hinged non interlocked doors or escutcheons and which carry a voltage higher than 25V AC or 60V DC shall be shrouded to IP2X to protect against accidental contact when the enclosure doors or escutcheons are open.

Appropriate warning labels shall be provided on shrouds.

4.3.10 Gland plates

Gland plates shall be constructed of the marine grade aluminium with appropriate gaskets. The gland plate shall be nominally 3 mm thick with 6 mm required where large cables or a large number of cables are to be glanded and be free from corrosion, dents and any surface defects.

25 mm wide neoprene gaskets shall be fitted to all gland plates and secured with 6 mm bolts at maximum 150 mm centres.

Access to both sides of each gland plate when it is in position shall be possible.

Gland plates shall be removable for drilling.

Gland plates shall be installed with spare holes (nominally 20%) to allow for future installation of cables without the need to remove and re-drill the gland plate. Unitywater personnel shall provide final acceptance on appropriate sizing and number of spare holes based on individual site requirements. Spare holes shall be sealed with threaded bungs. Spare blank capacity shall be left for further expansion or for larger glands.

Main incoming and outgoing sub-mains gland plates are excluded from this specific requirement.

4.3.11 Plinth

The plinth shall be a minimum 75 x 45 mm galvanised channel with rubber spacer to be provided between the plinth and the switchboard.

The plinth shall have M12 clearance holes for bolting to the floor.

The plinth shall be toe out.

4.3.12 Incoming feeder

Busbar flags, cable lugs and cable glands suitable for the size of the incomer cables shall be installed in the incoming termination area.

Cable glands (including those for neutral and earth cable) shall be mounted on the incoming gland plate suitable for the incoming circuit.

The distance from cable lugs to the gland plate shall be a minimum of 300 mm, but in any case, shall facilitate the ease of installation of large cables.

4.3.13 Busbars

Busbars shall be formed from hard drawn, high conductivity, solid round-edged rectangular tinned copper bar.

The current carrying surfaces of busbar joints shall be thoroughly cleaned to remove all traces of dirt and grease and shall be coated with a layer of corrosion-inhibiting jelly immediately prior to joining.

Connections shall be secured with high-tensile steel bolts and Bellville washers tensioned in accordance with manufacturer's instructions.

Dust and vermin proofing of the busbar chamber shall not be dependent on a seal between the cubicle walls and the floor but shall be by a complete metal enclosure. If ventilation is required in the bus chamber then the openings shall be covered with insect and vermin proof screens.

It shall be possible, by removing covers, to readily gain access to all busbar, riser and dropper joints in order to check their condition and general security. This shall not necessitate the removal of component mounting plates within sections.

A neutral busbar shall extend the full length of the switchboard and shall have take-off points sufficiently separated from live conductors to allow safe connection of circuit neutrals. Shrouding of neutral bars shall be provided within cables zones of switchboards and MCC or where there is a risk of accidental contact.

All phase and neutral bars shall be colour coded using bands at 300 mm intervals.

A minimum 31.5 mm x 6.3 mm earth bar shall extend the full length of the switchboard adjacent to the outgoing cable gland plates. The earth bar shall be colour-coded with green/yellow bands at maximum 300 mm intervals. The earth bar shall be tapped and fitted with bolts, washers and spring washers to accommodate the earth connections for all incoming and outgoing cables, with 20% spare connections.

For termination of field earth cables 2.5 mm^2 and smaller, an earth link bar with at least ten terminals shall be mounted on the earth busbar adjacent to each cable zone. Only one earth cable will be terminated at each earth terminal.

All parts of the switchboard which are required to be earthed shall be effectively connected to the earth busbar. Provision shall be made for the entry and termination of an earth cable at each end of the board, and for suitable terminals for connection to an earth core and/or steel armouring on all other incoming and outgoing cables.

Where the panel is likely to be extended in the future, the busbars should be drilled for extension.

Busbar sections shall preferably be installed at the top of the switchboard/MCC.

4.3.14 Main circuit rating and temperature rise

The main circuit supply rating required will be determined during the design. The main circuit shall provide this rating with a busbar temperature rise of not more than 30° C above ambient and within the temperature rise limits detailed AS/NZS 61439.1.

The busbar sizes shall be determined in accordance with the manufacturer's verified design.

Smaller busbars than those determined by the above method may be used only if an approved testing authority has carried out temperature rise tests on a switchboard with the same busbar sizes and similar internal configuration to the switchboard being supplied. Should this be the case, details of the test design shall be provided.

Regardless of busbar sizes, the temperature rise limits specified above shall not be exceeded.

Cables shall not be used in the main circuit supply except as permitted by AS/NZS 61439.1. When cables are used in the main circuit, they shall be double insulated.

4.3.15 Short circuit performance

The main circuit shall be constructed to withstand, without thermal or mechanical damage for 1 second, the short circuit stresses generated by the fault level stated.

The switchboard verified design shall have been successfully tested in accordance with AS/NZS 61439.1 by a recognised Australian testing authority. The design tested shall be applicable to the switchboard being supplied, i.e. it shall include feeders and motor starters if these are being supplied.

The switchboard being supplied shall be in no way inferior to the verified design of the tested switchboard, i.e.:

- Busbar ratings shall not be less than those type tested
- Busbar supports shall be identical in material and mounting method to those type tested
- Busbar support spacings shall not be greater than those type tested
- Phase centres shall not be less than those type tested
- Creepage and clearance distances shall not be less than those tested
- Feeder and motor starting equipment (circuit breakers, switch fuses, contactors, and overloads) shall preferably be the same equipment and in the same combination as that used in the type test (however, not every rating need have been tested).

4.4. Electrical equipment mounted within switchboards

4.4.1 General

All components of the switchboard shall be selected and installed so that all circuits can operate simultaneously at the full load rating shown on the drawings at the worst climatic extreme specified.

All equipment shall have front connection and removable cover plates shall be provided to permit ready access for this purpose.

All assemblies shall be vermin proof.

Indicating lights shall be LED type with colours as indicated on the design drawings.

4.4.2 Main switch/isolator

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. A correctly rated circuit breaker is preferred.

Main switches shall be of the auto or non-auto circuit breaker type.

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.

The main switch/isolator must have the ability for remote switching where it is rated above 400A.

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.

Irrespective of these requirements the Local Supply Authority requirements must be met.

4.4.3 Emergency supply transfer switch

Automatic transfer switches (ATS) shall be supplied with normal and emergency position auxiliary contacts for remote indication.

4.4.4 Circuit breakers

4.4.4.1 General

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
- Current ratings between 100 A and 1200 A – moulded case circuit breakers
- Current ratings over 1200 A – air circuit breakers (lower current rating may require ACB for some sites).

Prospective fault currents, protection and coordination calculations to ensure circuit breakers meet requirements shall be supplied as part of the design.

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.

Circuit breaker installation shall be within a cubicle or compartment.

Circuit breakers shall be logically ordered and shall be installed on the appropriate chassis or as a bus-bar/plug connection depending on the switchboard design requirements.

Each circuit breaker shall be labelled as per the electrical schematics and shall be padlockable in the OFF position.

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

Circuit breakers shall comply with AS 3111 or AS/NZS IEC 60947.2.

4.4.4.2 Moulded case circuit breakers

Moulded case circuit breakers shall have been tested by a recognised testing authority for compliance with AS/NZS IEC 60947.2. If this testing was not carried out within Australia, then a Certificate of Approval shall be provided from an approved Australian Electrical Distribution Authority.

MCCBs shall have the classification characteristics outlined in **Table 7: MCCB Classification Characteristics** in accordance with AS/NZS IEC 60467.2:

Table 7: MCCB Classification Characteristics

MCCB Characteristics	Required Standard
Rated Frequency	50 Hz
Rated Voltage	415 V AC
Rated Continuous Current	Rating shown of design drawing or in Schedule of Technical Requirements
No. of Poles	3
No. of Phases	3
Interrupting Medium	Air
Mounting	Withdrawable
Open/Close Mechanism	Independent Manual
Trip Units – minimum requirements	Inverse time, instantaneous
Interrupting Rating	Fault level on drawings or in the Schedule of Technical Requirements
Auxiliary Contacts	Required number for original design requirements plus at least 1 N/O and 1 N/C as spare
Short Circuit @ 440 V	P1 to IEC 947-2
Service	IEC 947-2

MCCBs used in motor power circuits shall be combined with the motor starter specification in Section 9 and shall be selected in accordance with the MCCB manufacturer's recommendations for the motor size.

Instantaneous only trip unit may be used for motor power circuits.

Instantaneous trip units shall have a maximum setting of at least 15 times the motor full load current.

Provision shall be made for padlocking each MCCB in the off position with door interlocking handle and padlock attachment.

4.4.4.3 Air circuit breakers

Air circuit breakers shall have been tested by a recognised testing authority for compliance with AS/NZS IEC 60947.2. If this testing was not carried out within Australia, then a Certificate of Approval shall be provided from an approved Australian Electrical Distribution Authority.

ACBs shall have the classification characteristics outlined in **Table 8: ACB Classification Characteristics**, in accordance with AS/NZS IEC 60947.2:

Table 8: ACB Classification Characteristics

ABC Characteristics	Required Standard
Rated Frequency	50 Hz
Rated Voltage	415 V AC
Rated Continuous Current	Rating shown of design drawing or in Schedule of Technical Requirements
No. of Poles	3 or 4 where nominated on drawings
No. of Phases	3
Interrupting Medium	Air
Mounting	Withdrawable
Open/Close Mechanism	Independent Manual
Trip Units – minimum requirements	Over current (L-S-I)/Earth Fault
Interrupting Rating	Fault level on drawings or in the Schedule of Technical Requirements
Auxiliary Contacts	Required number for original design requirements plus at least 1 N/O and 1 N/C as spare
Short Circuit @ 440 V	O – t – CO – t – CO as defined in AS/NZS IEC 60947.2
Service	AS/NZS IEC 60497.2

4.4.5 Fuse fittings and cartridges

Where fuses are allowed, 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.

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.

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.

4.4.6 Current transformers

Current Transformers shall comply with the requirements of AS 60044.1 and shall have the following characteristics in accordance with this standard:

Table 9: Measurement CT Requirements

CT Characteristics	Required Standard
Constructions	Window
Number of Primary Turns	1
System Voltage	415 V AC
Rated Frequency	50 Hz
Rated Primary Currents	Rating shown on design drawings
Rated Secondary Currents	1A or 5A

Measurement CTs shall also meet the following requirements:

- Type: M
- Accuracy Class: 1
- Rated Burden: 0.6Ω
- Rated Output: 15 VA.

Protection CTs shall also meet the following requirements:

- Classification: P
- Accuracy Limit Factor: 10
- Composite Error: 2.5
- Secondary Reference Voltage: 10.

Polarity markings shall be marked on each CT along with other information as required by AS 60044.1.

CTs shall be air insulated, with short circuit ratings not less than those of the circuits in which they are connected. They shall be mounted with P1 terminals adjacent to the busbars.

The polarity of primary and secondary windings shall be clearly indicated.

All CT secondary wiring except motor CT wiring shall be connected to test links which allow testing with 2 mm banana plugs.

CT wiring shall be 4 mm^2 minimum.

CTs for tariff metering on switchboard incoming supplies shall be installed in accordance with Local Supply Authority requirements.

Voltage connections shall also be made.

All current transformers shall be installed such that they can be readily replaced.

Sufficient space shall be provided for ease of installation of future additional CTs within bus zones of switchboards.

Rogowski Coils may also be considered when current measurement is required on an existing installation and there is difficulty installing a CT with the above requirements. Note that Rogowski Coils will not be accepted for new switchboards.

4.4.7 Motor selector switch

Not required on WWTP switchboards – refer Section 11 for field requirements.

4.4.8 Isolating switches

Isolators shall have a facility for padlocking them in the OFF position with the door open and closed. This facility must be an integral part of the isolating switch and the operating handle.

Isolation switches shall be provided with one NO and one NC early break, late make auxiliary contacts.

The isolator status shall be provided as an input to the site control system.

4.4.9 Motor protection relays/contactors

Motor protection relays shall be as per the requirements of Section 9 Motor starters.

4.4.10 Power monitoring

Electronic power meters shall have integral communications and comply with the requirements of Unitywater specification Pr9833 - Specification for SCADA and PLC Architecture.

Electronic power meters shall be front panel mounted and have a LCD type display that displays the selected readings from all three phases simultaneously.

Electronic power meters allow the user to define CT and VT ratios so that the display is in real units.

Electronic power meters be capable of measuring the following parameters:

- Instantaneous Voltage (3, min/max)
- Instantaneous Current (3, min/max)
- Demand Current (3 + N, min/max)
- Power factor (3, av.)
- kVA, kVAR, kW, kWh, kVA demand, kW demand (total)
- Frequency (av., min/max)
- Total Harmonic Distortion (THD).

Any special tools necessary for the maintenance or operation of the switchboard equipment shall be supplied.

4.4.11 Relays and timers

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 Unless otherwise specified/required and agreed with Unitywater relays shall have 4 poles per relay. Approval is required when deviating from 4 poles and may depend on the applications eg digital output relay, flow meter pulse relay.

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. Where possible timing/delay circuits are preferred to be driven by the system software.

4.4.12 Power failure monitoring

Power failure monitoring is to be performed by a dedicated phase failure relay (PFR). The PFR shall also monitor phase sequence.

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

The PFR shall be DIN rail mountable.

Following a power outage, once power is restored, the PFR delay contact shall provide an input to the control system to all the reset of all equipment automatically without any external intervention.

4.4.13 DC supply (control supply)

Power Supply Units shall have the negative output earthed at the output terminal. ELV supplies shall be nominated voltage VDC ± 10% for minimum and maximum actual load.

All equipment supplied by a DC voltage shall be fed from an appropriately rated DC circuit breaker.

4.5. Switchboard wiring

4.5.1 General

Wiring insulation shall be non-hygroscopic, incapable of supporting combustion and shall be capable of withstanding the service conditions to which it is subjected. Flexible V90-HT grade PVC insulated multi-strand tinned copper conductors are to be used for power and flexible V75 grade PVC insulated multi-strand tinned copper conductors for all other applications.

All wiring for power shall be not less than 2.5mm^2 (unless stated below).

All wiring for control, protection, metering, alarm and indication shall be not less than 1.5mm^2 (unless stated below).

Wiring to the plant control system and the marshalling terminals within the cubicle or immediately adjacent shall be single core 1 mm^2 flexible cable, unless using approved, purpose-built cabling and connectors.

Wiring carrying 4-20mA or similar low-level instrumentation signals shall be shielded pair, of not less than 1mm^2 cross section. Shielding shall be grounded at the PLC end only.

Switchboard wiring shall be colour coded as per Table 10: Wire Colour Code below.

When work is being carried out on an existing installation and the ELV control wire colours are not as per Table 10: Wire Colour Code, then for the existing switchboard, the ELV control wire colours shall match the existing installation. AS/NZS3000 requirements takes precedence over LV wiring.

Table 10: Wire Colour Code

Wire Type	Colour
Phase wiring	Red ('A' Phase), White ('B' Phase) and Light Blue ('C' Phase)
Neutral	Black
Single Phase Power Active	Red
Single Phase Control	Blue
Neutrals	Black
Earth	Green/Yellow
24 V DC Common Positive	Purple
24V DC Control (from first device or cubicle positive terminal)	Brown
24V DC Control Field (to field device – isolator etc)	White (Multicore Cable)
Field Digital Signals to PLC/RTU marshalling	White (Multicore Cable)
24 V DC Common Negative	Grey
Analogue I/O Field Connections and 'Pulse' signals (eg flow meters totaliser)	Screened Twisted Pair (White and Black) Cable
12 V DC	Red and Black Twin cable
Thermistor (Switchboard Wiring)	Orange
Thermistor (cable from switchboard to motor)	Screened twisted pair (White and Black) Cable.

Suitable bootlace terminals, lugs etc shall be crimped to the conductor before connection. Further details around terminations of wiring is detailed in Section 5.9 Terminations and Connections.

Connections to external control wiring and auxiliaries shall be through numbered terminal strips. Every terminal that connects internal wiring shall be large enough to accept at least 1.5mm^2 cables. Every terminal that connects external wiring shall be large enough to accept at least 2.5mm^2 cables for power cables and 1.5mm^2 for all other cables.

4.5.2 Wire duct and strapping

Where wiring is not run on cable tray in cable zones, wires shall be run in slotted insulated wiring duct fitted with a snap-on lid.

The slots shall be of the 'open' type so that it is possible to install or remove a wire without threading it through a slot.

Ducts shall not to be filled to more than 75 % of their full wiring capacity at any point within the duct after field cables have been installed. Care shall be taken to ensure that field cabling is allowed for in the duct sizing.

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

Plastic duct or cable trays shall also be provided for accommodating the incoming cable cores from the point of cable entry to the unit terminal block.

Plastic duct shall be mounted far enough from top to bottom of control gear to allow easy removal for service to remove and install associated wiring.

Where it is not practicable to run the wiring in ducts, wires shall be run in looms using flexible plastic spiral and cable ties at suitable intervals.

Wiring looms shall be supported adequately by a suitable approved means.

Ducts shall be arranged to allow wiring passing through the slots to be taken as directly to the terminals as possible.

Access to terminals shall not be impeded by the ducts.

Ducts shall not interfere with the mounting of equipment on any surface and vice versa.

Duct fixings shall not have sharp projections inside the duct which could damage cable insulation. Nylon set screws or nylon dome nut duct fixings are preferred.

The weight of wiring looms shall not cause any undue strain on the conductor strands or insulation. In particular, where a wiring loom crosses a door joint, the loom shall be arranged so that flexing across the hinge point is reduced to a minimum, and the wiring is firmly anchored on both sides. Permanent cable fixing supports shall be supplied on all hinged panels.

All groups and bunches of wires shall be run on sections of the cubicle that are free from projections such as small studs, etc. that may damage the conductor insulation.

Where wires pass through holes in panels, suitable bushes or plastic grommets shall be used.

ELV and LV wiring shall be installed in separate ducts. Hazardous Area wiring shall be separated from all other wiring.

4.5.3 Wire numbering

All wires (including earths) shall be uniquely numbered with the same number at each end of the wire. Numbering ferrules shall be fitted to each end of all separate lengths of control and power wire.

Wire numbers will change as they pass through a device. Wire numbers will not change when they pass through a terminal.

Wire numbering shall be in accordance with the drawings.

As a general rule wire numbers shall be prefixed by the origin device if no other format is defined and increment by 1 as it goes through the circuit. Further guidance is below and in **Table 11: Wire numbering examples**.

Wire numbers for control circuits shall be prefixed with the equipment number followed by an arbitrary incremental number e.g. MRT8101-1, MTR8101-2. The supply voltage wire number (positive and negative) may change only when it goes through a terminal to a motor cell for distribution within a cell (see Unitywater typical drawings for further examples).

Wire numbers for power supplies/control voltages shall be prefixed with the device it is fed from and the voltage e.g. Q101-24V, PSU1-0V. The wire number may change only when it goes through a terminal to a motor cell for distribution within a cell (see Unitywater typical drawings for further examples).

Wire numbers for power circuits shall be prefixed with the device number it is fed from and/or the phase colour for three phase circuits e.g. Q11-A-1, Q11-N, Q21-R-1 Q21-R-2, MTR8101-Q1-R-1, MTR8101-Q1-W-1, MTR8101-Q1-B-1. Wire number will increment by 1 as it passes through each device.

Wire numbers shall be affixed within suitable sized ferrules.

Ferrules shall have black letters on a background of white insulating material.

Circular type, slip-on ferrules or saddle type clip-on numbers shall not be used.

Ferrules are to be of an approved printed type, Brady-style ferruling system or similar i.e. where a single printed insert marker is inserted into a sleeve.

The same ferrule number shall be used on wires forming connections directly in series or parallel in the same panel.

Ferrules shall be arranged to read from left to right and from top to bottom.

Table 11: Wire numbering examples

Wire Number Type	Wire Number	Description
24V DC (Positive)	Q101-24V	Fed from Q101
0V DC (Negative)	PSU9101-0V	0V comes from PSU9101
Digital Input to PLC	2:1:DI05, 7:4:DI15	PLC Digital Input Rack 2, slot 1, Input 05, PLC Digital Input Rack 7, slot 4, Input 15
Digital Output from PLC	4:5:DO15,	PLC Digital Output Rack 4, slot 5, Output 15,
Analog Input to PLC	4:5:AI05	PLC Analog Input Rack 4, slot 5, Input 05,
Analog Output from PLC	6:3:AO04	PLC Analog Output Rack 6, slot 3, Output 04,
Motor – Red Phase	MTR0101-Q1-R-1, MTR0101-Q1-R-2 etc	
Motor – White Phase	MTR0101-Q1-W-1, MTR0101-Q1-W-2 etc	
Motor – Blue Phase	MTR-0101-Q1-B-1, MTR-0101-Q1-B-2 etc	
Power – single phase active	Q11-A-1	
Power – single phase neutral	Q11-N	
Instrument	FIT0101-1, FIT0101-2	Usually wire number will change to a PLC input number

4.5.4 Device Numbering

All devices within the switchboard shall be uniquely numbered.

Devices associated with particular equipment will be suffixed by the device number e.g. K1-MTR0101. Note that devices within motor cells will usually have the same device number as other motor cells however the suffix creates the unique device number.

Common Device type and identifiers are shown in Table 12 – some of these are also identified within Pr8843 - Specification for Drawing, Document and Equipment Tag Numbering, however where conflict arises this specification shall take precedence.

Table 12: Device naming conventions and identifiers

Device Type	Identifier	Description or example
Battery	G	
Changeover Switch (ATS/MTS)	Q	
Circuit Breaker	Qx	LV incoming CB isolator and those on the 'bus' (ACB/MCCB/CB)
Circuit Breaker – ELV Distribution	Qxyz	ELV Distribution (MCB)
Circuit Breaker – LV Distribution	Qxy	LV for general distribution (MCB)
Contactor	K	
Ethernet switch/managed/unmanaged switch	ENS	
Fuse	F	
General Purpose Outlet	GPO	
HMI	HMI	
Isolator	Q	
Motor Protection Relay	PR	
Phase fail relay	K	
PLC Output relay multi rack	DD:[Rack:slot:output]	
Power meter	P	
Power Supply	PSU	
Power Supply Redundant Module	PSR	
Power System protection relay	PR	
Pushbutton	S	
Radio	RAD	
Relay	K	
PLC	PLC	
RTU	RTU	

Device Type	Identifier	Description or example
RTU or PLC output relays	DDO[output number]	
Selector Switch	S	
Socket outlet – Not Switched	NSO	May be used for as a test point for RCD or where a switched outlet is not required.
Surge Diverter	Z	
Switched Socket outlet	SSO	
Terminal Strip	X	
Thermal Overload	F	
Timer	D	
Transient Barrier	Z	
VSD	VSD	

4.6. Auxiliary power requirements

4.6.1 General

Provision shall be made on all main switchboards for the connection of a permanent generator(s) for the site. Refer to requirements in Section 3.10.

Where a site has other auxiliary power requirements (Solar, battery, etc) specified in the project requirements then a dedicated feeder(s)/circuit breaker(s) shall be supplied within the switchboard.

Any other statutory or supply authority requirements must also be adhered to for auxiliary power supplies.

4.7. Standalone distribution boards

Distribution boards greater than 18 poles shall be a chassis type.

Distribution boards shall be designed for the application i.e. light and power, UPS supplied.

All distribution boards shall have a circuit legend adjacent to the distribution board or inside the door, clearly identifying all outgoing circuits. The legend shall show circuit numbers, current ratings of MCB, neutral link number (if applicable), cable sizes and type and load supplied. This legend shall be a drawing so that information is not replicated.

Distribution Boards shall be installed inside buildings.

It is preferable for distribution boards to be free standing and external to switchboards. However the following is provided if the distribution board is contained within the switchboard or MCC.

- Compartments enclosing circuit breakers and distribution boards shall be fitted with a hinged metal escutcheon mounted behind the compartment door, and the operating handles of the devices shall protrude through holes in the escutcheon.
- The escutcheons shall be latched with 316 stainless steel 8 mm solid square latch handles.

Doors for distribution boards shall have pintle hinges and be secured 316 stainless steel flush mounted swing handles.

An unobstructed exit route comprising a clear path of not less than 600 mm width when all compartment doors are open at right angles shall be provided.

Circuit breakers and isolators shall be padlockable in the off position. The padlock facilities shall not be dependent on the position of the escutcheon which shall be able to be opened with padlocks present.

Where the distribution board incoming circuit breaker or switch fuse is mounted on the escutcheon, the escutcheon shall be interlocked so that it cannot be opened unless the incomer is in the off position.

4.8. Other panels

Section reserved for future use.

4.9. Paint treatment of switchboards

The switchboard cabinet and exterior doors shall be powder coated mist green (AS 2700 colour G54).

The escutcheons and equipment panels shall be powder coated white (AS 2700 colour N14).

The surface of the switchboard metalwork shall be degreased and cleaned with solvent, then coated with electrostatically applied powder coat in accordance with paint manufacturers' recommendations.

The minimum paint thickness shall be 200 µm for mild steel boards and 75 µm for SS/MGA boards.

Additional touch up paint shall be supplied for any damage caused during transport and installation and left on site.

5. Installation requirements

5.1. General requirements

All locks supplied shall be master keyed to the requirements of Unitywater.

Each WWTP has its own allocated Bi-Lock key number with two levels of access, General and Control.

- General is intended for General Access for the WWTP site.
- Control is intended for Switchrooms and Electrical equipment.

If a lock requires a different barrel Unitywater will confirm during the project.

All equipment of similar nature and type shall be keyed alike.

Supports, brackets and plates for the mounting and positioning of electrical equipment shall be provided where necessary.

All supports, brackets and plates shall be 316 grade stainless steel.

Packers, shims and grouting may be used to ensure correct levelling and alignment of equipment.

Electrical equipment shall be mounted and positioned such that it is readily accessible for operation, inspection, replacement, modification and maintenance.

Mounting supports, brackets and plates shall be free from burrs and sharp edges.

Cutting of holes by burning methods will not be acceptable.

Electrical equipment shall be mounted on fixed structures. Where no fixed structure is available, self supporting stands or brackets shall be used.

All equipment shall be labelled as per the requirements of Section 16.

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.

Screws and bolts used for the mounting and fixing of electrical equipment shall be correct size and must not have excessive length.

All electrical equipment shall be accessible and mounted at suitable heights in accordance with Section 3.1.6.

Electrical equipment shall be positioned and mounted to allow bottom entry of conduits and/or cables.

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.

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.

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.

All critical electrical equipment at the site shall be mounted above Q100 levels.

5.2. Equipment, quality of materials and workmanship

All materials shall be new, except where existing equipment is specifically required to be reused and of the best quality and of the best class most suitable for working under the conditions specified. Further, they shall withstand the variations of temperature and atmospheric conditions arising under the working conditions without distortion or deterioration or the setting up of undue stress in any part, and also without affecting the strength and suitability of the various parts for the work that they have to perform.

Material having fire and vermin resistant properties shall, as far as practicable, be adopted throughout.

Equipment shall be installed so that it has the rating and settings shown on the drawings when the switchboard is in its fully operational and fully loaded condition, i.e. all covers and doors are closed, all circuits are at full load (as defined in this specification) and ambient temperature is at maximum (as defined in this specification).

All equipment shall be installed true horizontal or vertical and shall be mounted ‘square’.

Cables shall not twist or cross over unnecessarily.

Cables shall be tied in neat bundles when installed on cable ladders.

Glands shall be of the appropriate size and material.

The equipment shall be installed strictly in accordance with the manufacturer’s instructions in all regards, particularly concerning mounting, IP rating, clearances, enclosure sizes, temperature rise and maximum continuous current rating.

Equipment shall be securely mounted and braced so that movement cannot occur during operation under normal or fault conditions and so that adjacent equipment is unaffected and personnel operating the equipment are not endangered.

Equipment shall be selected for the installation location requirements. Where mounted in accessible places the equipment shall be mounted in such a way that it cannot be damaged by general operations.

5.3. Switchboard installation

5.3.1 Phase sequence

Phase sequence of the incoming supply shall be clockwise for all new main switchboard installations unless otherwise agreed and accepted by Unitywater electrical engineering personnel for valid technical reasons.

Where the incoming phase sequence is not clockwise, it is acceptable to transpose incoming phases. It is preferable to transpose the phases upstream of the main switchboard such that the incoming cables are still connected in R, W, B sequence at the PCC.

The same phase sequence as provided by the local supply authority to sub-mains, switchboards and multi-phase loads shall be adhered to throughout the installation. The phase sequence may be different for each site because of the HV network supplying the site.

For existing installations the phase sequence must be checked and sub boards must be as per the existing installation.

5.3.2 External switchboards

Where external switchboards are allowed, switchboards shall be mounted on an engineered 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.

A cable basement/cable way/conduits must be provided under the switchboard for cable entry.

Switchboards shall be positioned so that the doors do not open over locations where a fall or exposure to some other hazard may occur.

5.3.3 Internal switchboards

Switchboards shall be mounted on an engineered plinth and adequately secured to the floor ensuring the manufacturers requirements have been met.

A cable basement/cable way/conduits must be provided under the switchboard for cable entry.

For large switchboards/switchrooms a complete cable basement may be provided with associated cable ladder.

Where a cable basement is provided at least two (2) suitable access points must be provided to allow entry. Removable floor tiles are not acceptable access points where the cable basement exceeds a depth of 900 mm.

5.4. Wiring systems

5.4.1 Protection from fire, sun and mechanical damage

Wiring system classifications are described in AS/NZS 3013.

All components of the wiring system shall be suitable for the wiring system classification assigned to the wiring system.

All cables exposed to direct sunlight shall have UV stabilised sheathing insulation or shall be covered effectively and appropriately to comply with relevant Australian Standards. Usage of double insulated cables with an outer sheathing of non-UV-stabilized material shall not be accepted.

Cables must be protected from direct sunlight prior to installation. Further, cables must be stored to prevent them from being inundated by water. These conditions apply before, during and after installation.

5.4.2 Cables and conductors - general

All cables shall be new and shall be manufactured in accordance with AS/NZS 5000.1.

All cables shall have stranded copper conductors. Single solid strand conductors shall not be accepted.

A control or power cable must not contain a mix of LV and ELV voltages. Separate LV control cables and separate ELV control cables shall be installed, in accordance with separation and segregation requirements detailed in Section 5.8.5.

All cabling and wiring shall be supplied and installed in accordance with the applicable standards, in particular AS/NZS 3000 and AS/NZS 3008.1.1.

Cabling shall be of the size required to meet the current rating and voltage drop requirements of AS/NZS 3000 and AS/NZS 3008.1.1 for the actual circuit loading and method of installation or as specified in project requirements.

Cables shall be sized such that the steady state voltage drop on feeders to motors and other loads shall not exceed 3 %, with consideration given to current rating, short circuit rating and fault loop impedance.

All cables shall be sized to withstand without damage, the maximum fault level for the duration its protective device takes to disconnect the cable from the power source. Cables shall also be sized to enable the protection to operate correctly.

All cables that are to be installed below ground shall be Steel Wired Armoured (SWA). Single double insulated incomer cables to Main Switchboard or MCC and Variable speed drive cables (refer section 4.3.4) are exempt from this requirement.

Minimum size for cables external to the switchboard shall be:

- Power 2.5 mm^2
- Lighting 1.5 mm^2
- Control 1.5 mm^2
- Instrumentation 1.0 mm^2 screened (0.5mm^2 for switchboard internal wiring only)
- PLC I/O 1.0 mm^2 (0.5mm^2 for switchboard internal wiring only).

Power cables installed in below ground conduits shall be de-rated to suit the underground installation.

Any spare cores must be insulated and terminated appropriately, to prevent personnel injury.

5.4.3 Low voltage power cables

Multicore power cables with active conductor size 16mm^2 and above shall be orange circular, 0.6/1.0kV, with stranded copper conductors, X-90 XLPE insulated and V-90 PVC sheath and comply with AS/NZS 5000. Multicore power cables shall also include an insulated earth continuity conductor which shall be a stranded copper conductor with V-90 PVC sheath.

Multicore power cables with active conductor size 10mm^2 and below shall be orange circular, 0.6/1.0kV, with stranded copper conductors, V-90 PVC insulated and V-90 PVC sheath and comply with AS/NZS 5000. Multicore power cables shall also include an insulated earth continuity conductor which shall be a stranded copper conductor with V-90 PVC sheath.

Where flexible cords are used they shall be heavy duty, 0.6/1.0 kV, with stranded copper conductors, V-90 insulation, insulated earth continuity conductor and V-90 PVC sheath and comply with AS 3191.

Single core power cables shall be black circular, 0.6/1.0kV, with stranded copper conductors, X-90 XLPE insulation and V-90 PVC sheath and comply with AS/NZS 5000.1.

Thermoplastic-sheathed (TPS) flat cables shall not be utilised.

5.4.4 Variable Speed Drive cables (VSDs)

Variable speed drive cables shall be screened and EMC compliant. These include but are not limited to: Olex Varolex or Versolex or Siemens Protoflex or Triangle EU. Suitable EMC cable glands and reducers shall be used.

5.4.5 Submersible cables

Submersible pumps shall be fitted with the pump manufacturer's approved submersible cable.

All submersible cables shall be manufactured in accordance with AS/NZS 3191 and where applicable AS/NZS 5000.1 and shall be rated to a minimum submersion depth of 20 m.

Where a submersible pump unit has more than one power cable, then a Grade 316 stainless steel stocking shall be provided for each power cable.

All stockings of each submersible pump unit shall be connected together using a Grade 316 stainless steel D shackle of adequate size and rating onto a short single Grade 316 stainless steel wire sling, supported off a single Grade 316 stainless steel cable hook suitably rated and suitably positioned.

5.4.6 Control cables

Control cables shall be black or orange circular, 0.6/1.0kV, multi-core with stranded copper conductors, V-90 PVC insulation and V-90 PVC sheath and comply with AS/NZS 2373.1 and AS/NZS 3147. Multi-core control cables shall also include an insulated earth continuity conductor which shall be a stranded copper conductor with V-90 PVC insulation.

Control cable cores shall have white insulation and all cores shall be clearly numbered along the full length of the conductor in accordance with AS/NZ 5000.

The following principles shall be applied in allocating control conductors and selecting multicore control cables:

- Wherever practical and while complying with other requirements of this specification, all control conductors/core relating to one item of equipment (irrespective of whether the main item or an auxiliary item) shall be incorporated in the one multicore control cable. In such cases, the cable shall be terminated at a suitably located junction box from which other shorter cables should be installed to the individual connection points.
- Control cables shall have as a minimum three (3) spare control cores. Where cable length exceeds 30 metres or where subsequent installation of additional cables or a larger cable would be difficult or impractical this requirement may be increased.
- Voltage drop shall be taken into consideration in accordance with the requirements of AS/NZS 3000 and AS/NZS 3008.1.1.
- Wherever practical and while complying with other requirements of this specification, digital and analogue signals shall be separated into separate cables; and input and outputs should be separated into separate cables.

5.4.7 Instrumentation cables

Instrumentation cables shall be ‘Dekoron' or 'Instrolex' instrumentation cable or approved equivalent and shall be of multiple twisted pair construction utilising stranded copper conductors, each with V-90 PVC insulation. Each cable shall include an overall screen and drain wire, have a black V-90 PVC sheath and comply with AS/NZS 2373.2.

Instrumentation cables shall have each twisted pair in the cable uniquely identified by either colours or a numbers in accordance with AS/NZS 2373.2.

Instrumentation cables shall have as a minimum one (1) spare pair in addition to any specifically specified spare cores or cables. Where cable length exceeds 30 metres or where subsequent installation of additional cables or a larger cable would be difficult or impractical the cable shall have a minimum of 10% spare pairs. Field devices require a minimum of one (1) spare pair only. Final runs from a nearby junction box to the instrument does not require any spare pairs.

Cables running to field instruments shall have a circular external profile to enable a proper seal to be provided by the instrument cable gland.

5.4.8 Communications/data cables

All communications cabling shall be installed strictly in accordance with the manufacturer's recommendations and shall be suitable for use in an industrial environment.

Communication/data cables that are to be installed in below ground conduits/ducting shall be rodent resistant and of a type suitable for underground installation.

Ethernet cables and patch cables/leads shall be balanced 100 Ω, 4 Pair, Category 6 Unshielded Twisted Pair cable. All twisted pair cables shall comply with AS/NZS 3080.

Ethernet cables and patch cables/leads shall be coloured appropriately as follow:

- SCADA LAN Related cables – Yellow sheathing
- Control LAN Related cables – Green sheathing
- Telemetry network (WAN) related cables – Yellow sheathing
- Corporate LAN/WAN related cables – Blue sheathing

  NOTE: It is expected that patch cables will be used for final connections for the above. It is permissible to run Ethernet cabling that has blue sheathing as the backbone of the network which are terminated appropriately (i.e. wall plates/patch panel) then patch cables utilised with the above colouring. Cabling within switchboards shall comply with these colour codes.

Communications cabling shall be installed by an appropriately licenced tradesperson in accordance with AS CA S009 Installation requirements for Customer Cabling.

5.4.9 Optical fibre cables

Optical fibre cables shall be of the Multimode OM3, 50/125 µm type and comply with AS/NZS 3080, IEC60793-2 and IEC60794-1.

Optical fibre cables shall be a minimum of 12 cores.

Direct communication between specific devices (e.g. PLC to PLC for hot standby configuration) may require single mode optical fibre cables. This cable only shall comply with the requirements of the manufacturer to allow these communications to occur. This cable must be a minimum of 6 cores.

Optical fibre cables that are to be installed between the main functional/operational areas of the WWTP site and/or are required to pass through any of the main process areas shall be suitable for installation both internal to buildings and external to buildings.

Provision of a splice arrangement at the transition between internal and external/process area installation shall not be acceptable under any circumstances.

Optical fibre cables shall be suitable for installation externally within buried conduit or cable trench systems including cable pits that are not water tight.

Optical fibre cables installed within the confines of a single building and are to be located in areas not normally accessible to personnel may be rated for indoor installation only.

Internal to buildings, optical fibre cables shall be installed on cable ladders, trays or within cable ducts as applicable to each application. In such instances, cable ladders, trays and/or ducting must not be exclusive to optical fibre cables and must be able to accommodate other cables.

Optical fibre cables shall be of a construction type and duty rating to provide adequate protection in the environment which it is installed and for the intended application. All fibre optic cables shall also be rodent resistant.

Optical fibre cables shall be suitable for operation within a temperature range of -10^{o} C to +70^{o} C.

The manufacturer's minimum bending radius for the installation of fibre optic cables shall be adhered to.

Where any evidence of mechanical damage or optical performance degradation is recognised as a result of the cable minimum bending radius not being applied, the cable shall be replaced.

All cores of optical fibre cables shall be made off and terminated into an appropriate FOBOT.

Fibre Optic cabling shall be installed by an appropriately licenced tradesperson in accordance with AS S009 Installation requirements for Customer Cabling.

5.4.10 Instrument sensor cables

Instrument sensor cables shall be as supplied by or as recommended by the relevant instrument manufacturers and shall be provided with adequate length and mechanical and UV protection.

5.4.11 Underground installation – cable in conduit

Underground cables shall be installed in conduit.

Conduit fittings shall be sized so that cables are not bent to less than their minimum bending radius. Bends in conduits should be avoided. If they are essential they should be long radius type and few in number.

Minimum conduit size shall be 50 mm.

Where conduits are installed between cable pits, generally within the main service corridors, the minimum size conduit shall be 100 mm and a minimum redundancy of 50% shall be provided.

This redundancy requirement shall apply separately to each category of power, control and instrumentation (includes ELV), and communications.

Conduits should run at 90° under roads carrying vehicular traffic where practical.

A spare capacity of 100 % shall be provided (minimum of 2 spare conduits) where conduits pass under roads, footpaths and foundations.

Draw wires shall be installed in all conduits including conduits containing cables. Where cables are installed in the conduit the draw wire shall remain in the conduit after the last cable has been pulled for future use.

Underground conduits shall consist of rigid PVC conduits as follows:

- Power – Orange Heavy-duty uPVC conduit to AS/NZS 2053
- Control and Instrumentation – Orange Heavy-duty uPVC conduit to AS/NZS 2053
- Communications - White uPVC conduit, similar to Class 9 pressure pipe.

Corrugated conduit similar to Corflo shall not be utilised.

Power conduits shall be separated by a minimum of 200 mm from all other conduits (refer to Section 5.8.5).

All conduits shall have a minimum depth of coverage as specified by AS/NZS 3000 for LV cables.

5.4.11.1 Protection and marker tape

Mechanical protection shall be installed over underground cable systems including conduits for their entire route as required by AS/NZS 3000.

Mechanical protection shall be of approved proprietary manufacture consisting of either:

- Polymeric cable protection covers manufactured from orange coloured material. Paint or other orange coatings on the covers is not acceptable
- Precast bricks or precast concrete. Concrete covers cast on site or in situ are not acceptable

  AND

- Orange Polyethylene marker tapes, 150 mm wide and 0.1 mm thick, shall be laid in the trench directly over all underground conduits/cables at a depth of 150mm.The tape shall be marked with the warning "CAUTION ELECTRICITY" or similar in black letters that shall not fade.

5.4.11.2 Cable markers

Underground cable route concrete markers shall be installed above all underground cable runs at every change of direction and on straight runs at least every 30 m.

Markers shall consist of a concrete block 400 mm^2 and 100 mm deep with an engraved brass label attached. The marker shall identify the cable and indicate its direction of lay. Labels shall be fixed to the concrete block with screw fixings (not rawl plugs) and epoxy adhesive.

Markers in unpaved areas shall be installed with 20 mm projecting above the surface. Markers in paved areas shall be flush with the surface.

Where cables are installed below concrete slabs, markers may be affixed to the concrete slab.

5.5. Pits

5.5.1 Construction

Pits are required where cables installed underground need to transition through 90 degrees.

Cable pits shall consist of precast concrete pits with ductile iron lids. Pits, lids and the method of installation shall be suitable for the anticipated wheel loadings in the area in which they are installed. Pit lids shall be 600 x 900 ductile iron access covers and frames shall conform to AS 3996:

- Class "B" for non trafficable areas.
- Class "D" for trafficable areas.

Galvanised steel or aluminium lids may be used where the area is non-trafficable. Lids to electrical pits shall be marked ‘Electrical’.

Where dedicated pits are used for communications cables only, the pit lids shall be marked ‘Communications’.

Where a pit is shared for electrical and communication cables the pit lid shall be marked 'Electrical'.

Where water may collect in a pit, provision shall be made for its harmless escape through suitably located drainage points or a sump pump shall be installed. Where a sump pump is permanently installed SCADA monitoring must be provided for a sump overflow imminent level detection as a minimum. The sump overflow level imminent sensor shall be mounted below the controlled overflow if one exists or 100mm below the top of the sump. A single phase pump is acceptable in this instance connected via a GPO located outside of the pit.

5.5.2 Minimum size

Cable pits shall be:

- Adequately sized to accommodate the number of conduit entries.
- Allow the installation of cables without infringing on the minimum bending radius of the largest cable to be installed within the pit, during installation and when complete.
- The minimum length of cable pits shall not be less than 3 times the minimum bending radius of the largest bending cable.
- Minimum size of 600 mm x 600 mm x 700 mm deep.

Dimensions for all pits are internal dimensions at the depth at which the cable entry occurs.

5.5.3 Installation

Conduit entries into pits shall have bell mouthed ends correctly fitted and grouted.

Pits in paved surfaces shall be installed at grade with the surrounding surface.

Pits outside paved surfaces shall be installed 30 mm above the surrounding surface and the surrounding ground graded up to the pit for a distance of 1 m.

5.6. Conduits

5.6.1 General

Where cables are not installed on cable ladder or in underground conduit, they shall be installed in an open conduit system for cable support and protection.

Conduits shall have a minimum diameter of 25 mm.

Conduits shall generally be run as directly as practicable.

Conduits are to be run to enable cables to be drawn-in after installation. Draw ropes shall be braided polyethylene and fit for purpose.

Conduits shall be installed to avoid mechanical systems and other pipe services.

A sufficient number of accessible junction boxes shall be provided for this purpose.

Inspection fittings shall not be accessible as draw-in points, except where they are used in accessible surface runs of conduit to allow the conduit to pass around beams and other exposed structural members.

Conduit fittings shall be sized so that cable is not bent to less than its minimum bending radius.

Conduit shall be installed such that no part of the conduit is under mechanical stress.

The following are acceptable conduit material:

- Stainless Steel
- Aluminium
- HD uPVC.

Galvanised steel is not acceptable.

5.6.2 Surface run

Conduits shall be neatly run and securely fastened by means of stainless steel double sided saddles.

Saddles shall be provided within 150 mm of all fittings or terminations.

The direction of conduit run shall be parallel to the wall, floors and ceilings wherever practicable.

Surface conduits shall be run to be as inconspicuous as possible by running in corners and the like.

5.6.3 Cast in concrete

Conduits cast in-situ into concrete shall be orange Heavy-duty uPVC.

Where slabs and walls have a layer of reinforcement adjacent to each surface, the conduit shall be installed in the neutral plane between the two layers of reinforcement in such a manner that the reinforcement is not displaced in any way.

Deep or extension conduit boxes shall be used as necessary.

Conduit run between the reinforcement and the surface of the slab will not be permitted.

Where slabs or walls have only one layer of reinforcement placed centrally in the slab, the conduit shall be placed as nearly as possible to the centre of the slab without displacing the reinforcement.

A spare capacity of 50% shall be provided (minimum of 1 spare conduit) where conduits are cast in concrete.

5.6.4 Metallic conduit

All metallic conduits shall meet the requirements set out in the general section above (Section 5.6.1).

All metallic conduit shall be screwed and installed in accordance with AS/NZS 3000 and other requirements within this specification and in particular earthing.

All burrs shall be removed from ends and dressed appropriately to ensure cables are not damaged during installation.

All conduits shall be straight, free from rust and scale and any sets shall be made cold in such a manner as not to distort the walls of the conduit.

Conduits shall be supported not more than 2 m apart using stainless steel double saddles or unistrut and pipe clamps such that the conduit will be held in position without sagging.

5.6.5 HD uPVC conduit

Rigid uPVC conduit and fitting shall be in accordance with AS/NZS 2053.

Flexible conduit shall be limited to short section, not exceeding 500 mm in length where a conduit run needs to deviate around an obstruction.

All joints shall be cemented with an approved cement after cleaning with recommended solvent. For internal exposed conduits, clear cement jointing shall be used.

Conduit fittings shall be manufactured from rigid uPVC.

Stainless steel double saddles shall be used. Where necessary to eliminate sagging in the conduit additional saddles shall be provided.

Where uPVC conduit is installed across rafters or joists in roof spaces it shall be fastened to the side of a timber batten in accordance with relevant Australian Standards.

Saddles are to be provided within 150 mm of all fittings and terminations.

Where any section of rigid uPVC conduit exceeds 4 m in length an approved expansion joint shall be provided for each 4 m or part thereof along the entire length of the straight section.

All sets and bends in rigid uPVC conduit shall be made using internal springs of correct size to prevent wall collapse. Conduits in which any collapse of walls is evident will be condemned.

Precautions should be taken during construction to protect the conduits from damage or movement from position by other equipment being used.

5.6.6 Flexible conduit

Flexible conduit shall only be used to make final connection to individual items of equipment, e.g. motors, instruments.

The length of flexible conduit shall be kept to the minimum necessary to make the connection and accommodate equipment movement.

Flexible conduit type shall be suitable for the WS rating of the wiring system and the ambient conditions, such as sunlight, temperature, chemicals, etc.

As a minimum, flexible conduit in general use shall consist of non-metallic liquid tight flexible PVC with non-metallic uPVC reinforcing.

Corrugated uPVC conduit shall not be utilised as flexible conduit.

Flexible conduits shall be terminated with a correctly sized shroud over the conduit and gland to ensure no water ingress into conduit.

Where flexible conduit is used additional precautions must be considered and put in place to ensure that the IP rating of any enclosure is maintained.

5.7. Cable tray and ladder

5.7.1 General

All cable ladder, tray and duct shall be mounted to reduce build-up of dust and material.

Cables ladders shall, where possible, be of ample width to accommodate the cables specified with a 30% allowance for future cabling.

Where cable ladders may be subject to mechanical or UV damage the ladder shall be fitted with an approved cover.

External cable ladders shall have suitable covers installed. Where covers are fitted they shall be clamped to the ladder with proprietary clamps or appropriate galvanised or stainless steel self-drilling screws. Screws for covers/lids shall not be excessively long.

All cables shall be tied at suitable intervals. Stainless steel cable ties shall be used for all external wiring where exposed to direct sunlight or in hostile environments including but not limited to inlet works, sludge handling, chemical storage and dosing areas. Stainless steel cable ties shall be appropriately tooled off with no sharp edges

Power cables shall be installed in cable ladders with appropriate spacing to prevent de-rating.

Cables shall be spaced on racks to avoid build-up of material during normal operation.

Cable ladders shall be mounted to maintain 300 mm clearance between racks vertically and at least 150 mm under structural sections.

Subsidiary cable trays additional to cable ladders shall be installed where required to provide adequate support to cables.

Approved insulating separators shall be installed between the aluminium ladder or tray and steel supports or any other dissimilar metals interface and shall have a minimum thickness of 3 mm.

5.7.2 Metallic Cable Tray and Ladder

Metallic cable ladders, tray and associated brackets, fish plates, bends, tee pieces etc. shall be made of aluminium or stainless steel and shall be free of burrs or projections to prevent cable damage.

All nuts and bolts required for the installation of cable ladder shall be 316 stainless steel.

Cable ladders shall have a maximum rung spacing of 300 mm and be supported on fabricated stainless steel or aluminium brackets clamped or bolted to structures with 316 stainless steel bolts.

Cable ladders shall be rated to Nema 20C.

Cable ladder sections shall be bolted together and bolts shall not protrude in the rack section which may damage cables during installation.

Provision shall be made for expansion and contraction of cable ladder due to temperature, length of run, etc. to prevent buckling or distortion. Sliding joints shall be constructed such that abrasion of the mating surfaces does not cause removal of the anti-corrosion coating and suitable facilities for preserving earthing continuity shall be made at each sliding joint or gap. Care should be taken to ensure that cables are not fastened to the ladder in such a way that the cable is stressed during movement of the steelwork.

5.7.3 Non- Metallic Cable Tray and Ladder

Non-metallic cable ladders, tray and associated brackets, fish plates, bends, tee pieces etc. shall be made of UV and chemical resistant material.

All nuts and bolts required for the installation of cable ladder must be suitable for the selected ladder and may be proprietary in nature.

Cable ladders shall have a maximum rung spacing of 300 mm and be supported on brackets clamped to structures or bolted with 316 stainless steel bolts.

Cable ladders shall be rated to a minimum of 50kg/m, however the designer needs to confirm the actual tray loading based on the site cables.

Cable ladder sections shall be bolted together and bolts shall not protrude in the rack section which may damage cables during installation.

Provision shall be made for expansion and contraction of cable ladder due to temperature, length of run, etc. to prevent buckling or distortion.

5.8. Cable Installation

5.8.1 General

Upon delivery of the cable drums, they shall be visually inspected for damage incurred during transport or storage.

The seal on the inner and outer cable end shall be examined and the condition of armouring, serving or sheath inspected for damage, corrosion or leakage of impregnating oil.

During installation cables shall be handled with due care. When pulling cables, any winch used shall have automatic tension limiters and the tension shall not exceed that specified by the manufacturers for the particular cable and conditions of installation.

Winching ropes shall be attached to the cable armour with steel mesh sleeves and care shall be taken that cable sheaths are not damaged in any way.

When laying or snaking the cable, no twists or kinks shall be allowed to occur.

Throughout the installation, twisted, kinked, knotted or crossed cables shall not be permitted. This includes but is not limited in any enclosure and from cable ladder to conduit.

When drawing cable into conduits only chalk type or other approved lubricants not injurious to PVC sheathing may be used. Petroleum based substances such as grease or oil are not permitted.

When rollers are used during installation, sufficient units shall be placed to keep the cable clear of ground and other obstructions. Vertical rollers shall be used at all changes of direction.

Cables shall not be bent to a radius less than that recommended by the manufacturer.

Should any damage occur to any part of a cable during handling or installation then approval by Unitywater shall be sought prior to works continuing

5.8.2 Switchboards within switchrooms

Except where installed into underground ducts (conduits) formed from buried pipes, all cabling shall be supported by continuous cable ladder support systems. This shall include cabling within covered, pre-formed concrete floor trenches or cable ways below switchrooms.

Cables shall not be fixed directly to the base or sides of trenches.

Cable containment and/or support within the cable pit/basement is required.

Each MCC will be arranged for cable entry from below for all incoming and outgoing circuits.

Beneath each MCC, cabling shall be installed onto multiple formations of cable ladders and/or cable trays as appropriate to the sizes and combined weights of the cables and taking into consideration the cable current ratings for each type of support.

Cables with outside diameters of 35 mm and above shall be run in a single layer and fixed to cable ladder supports with the exception of SDI mains cable which shall be installed in trefoil.

All cable apertures conduit entry and duct penetrations into buildings including spare ducts shall be sealed, maintaining the fire rating of the respective building and to prevent vermin entry.

Other openings, ducts, trenches, cable ways or the like made for the entry of electrical conduits and cables through external walls of buildings shall be sealed with a suitable compound to allow future cable installation. Sealing compound shall be as per F10678.

The method of sealing conduits shall prevent vermin entry.

All spare conduits and ducts shall be effectively plugged and sealed.

Cables to variable speed drives shall be installed in accordance with the manufacturer's recommendations with due allowance (as required) for additional hardware such as filters or output chokes to compensate cable length, separation from other cables, screening and earthing as required. Cables should cross other cables at right angles to minimise radio frequency emissions.

5.8.3 Wiring method

Cables shall be installed in continuous lengths.

Jointing of cables and use of connectors will only be permitted at outlets or suitably positioned junction boxes.

Wiring shall not be run through fittings.

Wiring shall enter and leave at the one point.

Wiring shall be protected by conduit where exposed to the risk of damage.

The design and selection of wiring systems shall be suitable for the external influences that they will be exposed to at the point of installation and at site, in accordance with AS/NZS 3000.

5.8.4 Support and protection

Cables shall be routed and adequately supported on cable ladders or trays.

Where cables leave the ladder or tray for short lengths they shall be run in conduit.

Cables installed 1500 mm below finished surface level shall have additional mechanical protection in the form of the following:

- Conduit systems
- Aluminium channel, etc.

The use of Ramset nails for support of cables or cable supports is not acceptable.

Conduit, cable ladder covers, duct or other approved installation method shall provide protection of the cables from sunlight exposure, and associated UV damage, along their entire length.

5.8.5 Segregation

The minimum separation distances shall be as follows:

- LV Power cables to all other cables (except HV) > 200 mm
- ELV cables to data/communications/fibre optic > 100 mm
- HV cabling to LV cables >600mm
- HV cable to ELV or data/communication cable/fibre optic >900mm.

The preferred way to separate cables is via separate cable ladder/trays. Where it is not suitable to install multiple cable ladders/trays, cables may be separated by a continuous barrier made of the same material as the cable ladder/tray.

5.8.6 Cable slack

Slack shall be provided at termination boxes and equipment to facilitate servicing and re-terminating.

All cables shall be routed and terminated to provide extra length for future re-termination.

Cables into LCS must incorporate a ‘service loop’.

5.8.7 Single core cables

Single core cables forming part of a three-phase system shall be clamped together in trefoil over their entire route to avoid de-rating.

The configuration of parallel trefoil circuits shall comply with the recommendations of AS/NZS 3008.1.1 Appendix B. This configuration requires that the phase arrangement in one cable group shall be a lateral mirror image of the phase arrangement of the adjacent group.

The clamping of single core cables in trefoil shall be of sufficient mechanical strength to withstand the forces generated by fault currents.

Single core cables shall be installed so as to avoid hysteresis and eddy currents in surrounding metal work or cleating and shall be glanded through non-ferrous material.

5.9. Terminations and connections

5.9.1 Terminations

All conductors shall be terminated with approved crimping lugs, crimping pins or bootlace crimps.

Conductor terminations shall be applied using an approved certified tool with a ratchet action.

Where hand operated crimping tools are used, the tools shall be of the type which will not release until full compression is applied.

Hexagonal crimping dies shall be used on all cables of 10 mm^2 cross section and above.

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 to be terminated.

Lugs shall be of the type most suited to the device terminal, e.g. fork tongue for stud terminals and wire pin type for tunnel type terminals.

Bootlace crimps shall be used up to 10mm^2 and crimping pins shall be used above 10mm^2.

Only one wire shall be crimped in each terminal lug or pin except where a terminal lug is specifically designed for more than one wire to be terminated. In this instance then multiple wires may be crimped but only up to the designed number of wires.

There shall be no jointing or teeing of wires between terminals.

Not more than one wire shall be connected on any termination point of any tunnel type terminal.

Where multiple connections are required on tunnel terminals, multiple terminals linked with proprietary terminal link bars, proprietary combs or suitable terminals from F10678 - Accepted Electrical Equipment List shall be used. Only where more than one link is required, wire bridges will be permitted.

Suitable full sized bolts shall be used for the connection of lugs onto equipment screw terminals.

Terminations shall ensure that no extraneous force exists on any cable, core or device when installation is complete.

Screws shall not directly contact the conductors.

Terminals shall be generously spaced to provide easy access to the terminals of any circuit, and to prevent accidental contact with live circuits in the same compartment.

Terminals shall be numbered consecutively from top to bottom and left to right.

Each group of terminals shall have a unique designation for each panel and shall generally be identified as X1, X2, X3, etc.

The numbering for each new terminal group shall start at one (1).

Barriers shall be provided on all terminal banks to group terminals into logical divisions.

Where control cables and power cables (above 50 V DC) are connected to terminal strips in the same enclosure, approved protective covers and warning labels shall be installed over power connections. The power terminals shall also be separated by suitably sized terminal barriers.

Control terminals shall be mounted so that the wire numbers on both sides of the terminal are readable from the front of the switchboard with covers or doors open.

Control terminals in Form 3 or above switchboards shall be mounted in cable zones (not within the modules), within 150 mm of the front of the switchboard for easy access.

5.9.2 LV terminations

All cables shall be installed and terminated using fittings appropriate to the situation.

The unsheathed part of multicore cables shall be neatly laced.

5.9.3 Cable glands

Cable glands shall be of an approved weatherproof type that is consistent with the IP rating of the enclosure and the hazardous area classification (if applicable).

As a minimum, glands in general areas shall be constructed from:

- Cables up to 32 mm gland size: Nylon or PVC
- Cables larger than 40 mm gland size: Nickel-plated brass
- SWA Cables: Nickel plated brass
- Screened VSD Cables or other special purpose: EMC Gland (sized appropriately).

Nickel-plated brass glands shall not be used in conjunction with aluminium alloy boxes or Aluminium gland plates.

All gland plates shall be drilled to the sizes required by the cable gland. The gland sizes shall conform to the manufacturer's recommendations.

Where it is required that PVC cables be connected to equipment that is too small to accommodate the gland, or if permanent wiring is provided with equipment (e.g. solenoid valves), then cables shall be terminated in a conveniently located two-way junction box. Cable entry into equipment must still comply with the IP rating required for the installation. Unitywater may provide approval for the use of PVC junction boxes in these instances only.

Connections to equipment from the junction box shall be made using flexible conduit and approved fittings. The enclosure rating of the junction box and fittings shall be appropriate for the area of installation.

Cabling into enclosures shall be bottom entry only.

Each gland shall accommodate one cable only. Multiple cables shall not be allowed into a single gland.

Cable glands shall be correctly sized for the cable.

5.9.4 Power circuit connections

All power cables shall be connected with a suitably sized lug unless the equipment (circuit breaker or contactor) has tunnel type terminals.

Power circuit connections shall be made with high-tensile, electroplated steel or phosphor bronze bolts with a large flat washer and spring locking washer under the bolt head.

It shall be possible to check the tightness of all connections by removing covers, if necessary, when the switchboard is completely assembled.

Provision shall be made in the termination area to allow circuits to be checked with clip-on type ammeters.

Power cables to the load shall be terminated directly on their source of supply. Power terminals of different phases shall be separated by additional barriers unless the terminal design incorporates such barriers as standard.

5.9.5 Numbering of cables and wires

All cables shall be identified at each end where they are connected to apparatus using stainless steel identification labels where the label is installed outdoors and plastic (Non-conductive) label when installed within a switchboard/indoors. The identification used shall correspond to that shown on the drawings and shall comply with Unitywater numbering requirements outlined in Pr8843 - Specification for Drawing, Document and Equipment Tag Numbering.

All stainless steel cable labelling shall be etched 316 stainless steel and fixed by appropriate means, i.e. stainless steel cable ties for external plant areas and appropriately tooled off (no sharp edges), nylon cable ties may be used for cable labels within buildings or enclosures.

All plastic (Non-conductive) cable labelling shall be Brady-style system or similar where a single printed marker is used.

Cables shall be labelled on both sides of a gland plate for all switchboards and MCC. For other switchboards and equipment, cables shall be labelled on both sides of the gland plate where both sides of the cable cannot be touched by one person at the same time.

Numbering ferrules shall be fitted to each end of all separate lengths of control and power wire.

Ferrules shall have black letters on a background of white insulating material.

Circular type, slip-on ferrules or saddle type clip-on numbers shall not be used.

Ferrules are to be of an approved printed type, Brady-style ferruling system or similar i.e. where a single printed insert marker is inserted into a sleeve.

The same ferrule number shall be used on wires forming connections directly in series or parallel in the same panel.

Wires shall be numbered in accordance with the drawings. Wire numbers on wires which leave the equipment module (in form 3 switchboards) shall be prefixed with the equipment number.

Ferrules shall be arranged to read from left to right and from top to bottom.

6. Earthing

6.1. General

Earthing design requirements are shown in Section 3.5.

Termination requirements are shown in Section 5.9.1.

Earthing installations shall comply with the recommendations, regulations and requirements set out in AS/NZS 3000, the Electrical Supply Authority and relevant Acts and Regulations.

Where necessary, a site survey shall be carried out to determine soil resistivity and hence the optimum type, quantity and arrangement of earth electrodes in order to achieve the required resistance, together with any grading electrodes needed to control potential radiant around each building and tanks, etc. for the installation. These requirements shall be incorporated, as required, into the civil/structural design.

Main earthing conductors shall be provided from the main switchboard, main earth bar to steelwork, incoming services, etc., in accordance with AS/NZS 3000 and to the following:

- Main earth electrode installation
- Motor control centre or other switchboard earth bars
- Distribution board earth bars
- Mechanical Equipment.

No earthing system shall rely upon the metalwork of plant or equipment for earth continuity.

All materials used for earthing and bonding shall be suitable for the local site conditions and steel, aluminium and galvanised metal should not be used.

All doors for switchboards, MCC, Control panels, panels, LCSs shall be effectively earthed to the case by means of flexible connection not less than 4 mm² to a door stud.

The gland plate for all switchboards, MCC, Control panels, panels, LCSs shall be effectively earthed to the case.

Hinged joints carrying wiring shall be provided with flexible earth bonding strap of adequate size.

Cable ladder routes shall be bonded to the plant earth.

6.2. Equipotential bonding

Equipotential bonding as a minimum shall include buried earth straps with brazed connections from main earth grid to all the below items:

- All items of process plant
- Metallic pipework
- Structural metalwork
- Concrete mesh and steel
- Hand rails
- Pole bases
- Any lightning protection systems
- Cable supports located within cable pits
- Any extraneous conductive parts.

All metallic cable ladder and other supports shall be earthed.

All expansion joints in cable ladders and cable trays shall be bonded to ensure continuity.

The minimum size bonding and earthing conductors for cable trays/ladders shall be as per AS/NZS 3000 for the largest active conductor.

If the use of pipework or equipment with specialised non-conductive surface preparations cannot guarantee earth continuity, notably across flange joints then earth bonding conductors shall be installed to ensure continuity.

Earthing points shall be provided on all electrical enclosures. Metal covers requiring access by service personnel or similar, shall be fitted with an earth strap to ensure a permanent and continuous bond to the earth of the main body of the unit, even when removed.

All enclosures and items of mechanical equipment shall be effectively earthed. Starred washers are preferred for mounting pans.

All metal gland plates shall be earthed.

Glands fitted to plastic or painted steel gland plates shall be earthed using proprietary gland earthing lugs.

Radial connections to both the earth grid and equipotential bond systems shall be PVC yellow/green insulated, crimped with an approved ‘C’ connector to the grid/bond conductor and lug bolted to equipment.

Multiple earth connections within equipment shall terminate at earth bars with one conductor per screw, stud or tunnel type terminal. Tunnel type terminals shall have two screws.

6.3. Surge protection

Surge protection shall be installed on equipment and cables exposed to lightning strikes or electrical switching surges.

Power conditioning equipment and surge protection devices shall be fitted for protection against voltage disturbances.

Combined surge protectors and radio frequency filters shall be used for the power supplies to:

- Computers and related equipment
- Telecommunications equipment
- Electronic equipment such as closed circuit TV systems, public address and communications systems, radio base stations and the like
- Control system equipment
- Mains powered instruments
- Fire equipment – including all Fire Indicator Panels (FIPs)
- Field instrument and communications circuits at particular risk of induced voltages due to lightning strikes or electrical switching shall be fitted with surge protectors at both the instrument and at the control system termination panel. Such circuits shall include:
    - Instruments fitted in open exposed locations
    - Instruments located on the top of a building
    - Instrument and communications circuits that run between buildings
    - Circuits directly connected to power transformers or large LV motors (such as embedded RTDs or thermocouples in the motor windings).

6.4. Lightning protection

Lightning protection shall be installed on equipment and cables exposed to lightning strikes or electrical switching surges.

Lightning protection shall be designed and installed in compliance with AS1768.

Lightning protection shall be designed to protect personnel and equipment from direct strike or indirect step and touch potentials as a result of a lightning strike.

Lightning protection equipment shall be earthed to the main earth system.

6.5. Instrument earthing

Instrument earth bars, where required, shall be provided in switchboards, instrument junction boxes or any other panel that instrumentation is distributed from.

Instrument earth bars should be separate to the main earthing system.

Instrument earth bars shall connect to the main earth bar.

Where screened cables are used for instruments the screen shall be earthed at the instrument earth bar only and not at the instrument.

The screen shall be continuous from the instrument to the earth bar.

7. Control system

7.1. General requirements

The plant control system shall generally consist of the following equipment PLC, remote IO, servers, work stations, managed switches, modems, unmanaged switches, signal converters, HMI, motor starters, antennas, fibre optic links, RTU, radio (although RTU and radio are not commonly used at WWTP sites).

The plant control system will generally have two (2) separate dedicated networks:

- SCADA LAN
- Control LAN.

Where devices connect to the SCADA LAN the Unitywater OT team will need to be consulted.

Further information and details can be found in the following specifications:

- Pr9833 - Specification for SCADA and PLC Architecture
- Pr9834 - Specification for SCADA Standard
- Pr9844 - Specification for SCADA and PLC Device Type - Siemens
- Pr9845 - SCADA and PLC Implementation Specification
- Pr9846 - SCADA and PLC Historian and Reporting[1] Specification
- Pr10434 - Specification for SCADA and PLC Device Type - Siemens OPC
- Pr10699 - Treatment Plant PLC and SCADA Specification - Device Type Schneider PLC.

[1] *Reporting is ad hoc and site specific at present due to the inability to comply with Pr9846 - SCADA and PLC Historian and Reporting Specification. Future works will develop a reporting specification.*

7.2. Control system

7.2.1 General

All control system equipment shall be mounted within dedicated sections of switchboards or within a standalone panel, except for device related equipment (i.e. motor starters, HMI) and externally mounted equipment (i.e. antennas).

All control system equipment will be mounted on a removable mounting pan in the compartment.

All wiring connections from pan-mounted equipment to other areas of the switchboard or to external devices shall be made via a common terminal strip located on the mounting pan.

Third party control systems will generally not be accepted unless there is a valid technical reason that the control cannot be carried out within the site control system.

Unitywater requires integration/programming to be carried out by competent and skilled personnel only. Integrators/programmers shall ensure that their code meets the requirements of the specifications detailed in Section 7.1.

Unitywater has standard libraries for integration into PLC and SCADA systems. These libraries shall be used in developing the control system code as well as to ensure all devices communicate the required signals back to the control system.

The control system design shall complement the electrical design to ensure full functionality and monitoring of equipment is achieved.

In case of abnormality such as power supply failure, field device failure, contact failure all inputs/outputs shall be programmed for a process ‘safe state’.

Where the current Unitywater control platform is not suitable for the systems supplied, Unitywater Operational Technology team and Unitywater Infrastructure Standards team are to consulted to provide a decision and direction.

Where third party controllers are approved by Unitywater for a site, all programming cables and software licences shall be supplied to Unitywater at completion of the project. All code shall provided in at least a ‘read only’ state. Training in regards to programming and replacement shall be provided. Where a system is deemed critical a backup controller/PLC pre-programmed and ready for installation may be required. This detail will be specified during the project lifecycle.

Installation and mounting requirements shall be as per Section 4 and Section 5.

7.2.2 PLC equipment

All equipment shall be arranged to simplify servicing and shall be readily accessible for routine inspection, testing, normal replacement and maintenance of components without the necessity to dismantle or remove other equipment or cabling.

For hot standby PLCs each PLC shall be physically separated in separate buildings. If this requirement cannot be met, then approval is required from Unitywater Operational Technology Team and Unitywater Infrastructure Standards Team. If approval is given to install PLCs within the same building/room then at a minimum the PLCs shall be separated into separate physical compartments of the switchboard or MCC or in physically separate panels within the same room.

PLCs shall include a processor, inputs and outputs, communications interface, watch dog timer and real time clock/calendar and all other facilities necessary to ensure successful operation.

Input and Output allocation requirements are:

- Whenever possible, signals shall be allocated to input and output modules in a manner consistent with the process plant equipment ensuring that the failure of any one module does not affect more than one item of plant or equipment.

Spare Inputs and Outputs requirements are:

- Following commissioning of the plant, at least 1 or 20% (whichever is greater) of each type of input and output module shall be available as installed spare.
- Similarly, the PLC and each remote IO rack shall be able to accommodate at least two additional input and/or output modules in the future. Sufficient space in the installed input/output module equipment racks shall be provided for the future modules.
- This requirement may be relaxed at the discretion of the Unitywater Operational Technology Team and/or Unitywater Infrastructure Standards Team based on project size and future requirements of the particular area of installation.

Termination requirements are:

- Input/Output modules shall be provided with detachable terminal strips to facilitate module exchange without reference to the panel wiring.
- Each wire shall be identified with the I/O number as per 4.5.3.

The PLC CPU shall constantly perform self-checks to identify any memory, system program or user programme faults.

The power supply, battery, I/O bus and cycle time shall be monitored.

In case of abnormality such as power supply or CPU failure, all outputs shall be programmed for a process ‘safe state’ if there is no hot standby PLC or the hot standby PLC does not take over control.

The PLC shall be provided with a self-test facility which can be activated by service personnel only. This facility shall test the correct operation of the major elements of the PLC.

The PLC shall be suitable for operation from a nominal 24 VDC power supply. The PLC power supply shall include galvanic isolation complying with that specified for the digital inputs.

7.3. SCADA

7.3.1 General

SCADA requirements are detailed in relevant specifications as listed in Section 7.1 above.

Unitywater will manage any hardware and installation within the SCADA LAN.

7.4. Networking

7.4.1 General

Networking of equipment shall generally be via managed switches located at convenient locations around the site with a fibre optic connection between locations.

Unmanaged switches are generally not acceptable in WWTP applications.

7.4.2 SCADA LAN

The SCADA LAN shall be utilised for the connection of IT infrastructure to manage the SCADA system.

Unitywater usually configures and controls all access to the SCADA LAN.

7.4.3 Control LAN

The Control LAN will connect devices to the control system and shall be ethernet based.

Each site has a fixed IP address that is allocated and configured by the OT Team. Device IP addresses are not the responsibility of the OT team unless otherwise agreed.

7.4.4 Fibre Optic

A fibre optic backbone is the required link between nodes around the site. The fibre optic cable shall be terminated into an appropriate FOBOT as per the requirements of Section 5.4.9 and will then use patch leads to connect devices.

It is preferred that the fibre optic backbone forms a ring around the site with minimal spurs. Spurs may be used for non-critical control system equipment only.

7.5. Communications

7.5.1 Modems

Modems are used for paging alarms to operators. Modems shall be of the mobile type and shall utilise a free issued sim card.

The modem will connect to a dedicated Unitywater private APN.

Unitywater will configure the modem and sim card for access to this network.

Modems shall be mounted within a suitable enclosure and may require an external antenna to ensure consistent mobile signal strength is maintained. Sections 4, 5 and 7.5.3 provide details of suitable installation requirements.

7.5.2 Radio

Radios are note commonly used on WWTP sites. If a radio is to be used, then Unitywater Operational Technology team and Unitywater Infrastructure Standards teams are to be consulted to provide a decision and direction.

7.5.3 Antennas and poles

Where required, antennas may be required for radio or telecommunication devices.

A radio survey shall determine an acceptable antenna selection, mounting location and direction of orientation.

The radio survey result shall be used to guide an acceptable antenna mounting strategy.

The preferred antenna location is on a 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 separate dedicated communication pole. The pole may be a galvanised/powder coated tapered steel or aluminium pole or a wooden pole.

A separate communications pole may be required depending on the results of the radio survey.

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.

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 repeater base station, as per the radio survey and be capable of rotation towards other repeater base stations.

Where there is a requirement to mount multiple antennas on the same pole or the same location, they must be separated by a minimum of 1m.

7.5.4 Microwave

Section reserved for future use.

7.6. Communications Racks

Dedicated communications racks will be installed at WWTP sites. Typically there will be at least two communication racks per site to house hardware associated with IT/OT for the site.

Power to communication racks must be supplied by a general purpose outlet and a UPS backed general purpose outlet to ensure power continuity.

8. Instrumentation Technical Specifications

8.1. General technical requirements

8.1.1 General

All instrumentation shall be installed in accordance with manufacturer's instructions and, where applicable and appropriate, to Unitywater's standard electrical drawings.

Instrumentation includes primary measuring elements and associated instrument transmitters for sensing of physical plant variables for monitoring and/or control purposes.

The most suitable type of instrument shall be selected for each application. Suitability shall be assessed based upon reliability, response time, accuracy and the amount of maintenance required. Instrument make and model shall be in accordance with the Mandated Equipment List. Instruments shall be bus powered or loop powered. Separately supplied instruments are not allowed.

All instruments shall be supplied from UPS backed systems and shall have all measurements integrated into the plant control system.

Analogue instruments shall use Profibus PA communication protocol or 4-20 mA HART communication protocol only. No other field bus signal types will be considered. Transmitters providing the specified signal types shall be located as close as possible and preferably integral to process elements. Transmitters shall be provided by the same vendor and shall be specifically designed to work with the process element.

All instruments shall have a local display in the field with the display indicating absolute values in metric engineering units. 0-100% scales are not acceptable.

Wherever practicable, all controls and instrumentation located in the field shall be conveniently grouped for operational ease.

Where an analogue instrument is field mounted its signal shall be surge protected both local to the instrument and local to the associated PLC analogue card.

All instruments with data exchange capability shall be configured for remote and online interrogation, configuration and diagnostics over the communications channel with the relevant software installed on the Engineering Workstation.

Discrete outputs of all digital instruments shall be voltage-free contacts rated for at least 1A at 250V AC and 1A at 24V DC.

Instrumentation earth bars shall be provided at convenient locations throughout the installation.

Where screened signal wires are specified, screening shall be continuous from the signal source to the receiver. Earthing of the screen shall be at the MCC/PLC end only and shall be achieved by connection to the instrument earth bar. Heat shrink shall be fitted to the ends of instrument cables.

Final connections to instruments and similar equipment, which are withdrawable from its mounting, shall be made with flexible conduit entries in PVC double insulated flexible cable not less than 0.5 mm². Sufficient length, neatly strapped, shall be provided to permit easy withdrawal of equipment.

Special calibration devices and equipment are to be supplied e.g. programmers, cal-cubes, etc. where required.

All underground equipment shall be installed within a suitably sized pit. Pits shall also be provided with adequate drainage to the plant or a sump pump shall be installed. The requirements of Section 5.5 also apply to instrumentation installed in pits especially in regards to drainage.

8.1.2 Accuracy

The accuracy of each instrument shall be within +/-2.5% of span unless otherwise required for process control.

Accuracy shall be defined as follows:

- For primary elements and their associated signal converters/transmitters: The accuracy shall relate the analogue signal output to the physical process variable.
- For secondary instruments, accuracy shall relate the output signal, indication or pen record (as appropriate) to the analogue input signal.

All instruments shall be suitable for continuous unattended operation and shall maintain their rated accuracy with a minimum of maintenance or need for calibration and adjustment.

8.1.3 Circuits and components

Circuits and components shall be standardised for all similar applications to facilitate design, construction, testing, operation, maintenance and calibration. They shall be readily available within Australia and be arranged and designed to form a simple, safe and reliable system allowing rapid removal and renewal of components as required.

Integrated circuit devices shall be used wherever possible.

All equipment shall be suitable for operation in the vicinity of other electrical equipment and shall be immune to electromagnetic interference when subjected to field strengths up to 10 V/m over a frequency range of 10 kHz to 1000 MHz.

Electromagnetic interference and high frequency distortion of the terminal voltage generated by the operation of equipment shall not exceed the limits defined in AS CISPR 14.1.

Instrumentation earthing shall be to a separate earth bar in switchboards or control panels.

8.1.3.1 Output

The analogue output of all electronic signal converters, transmitters, controllers, etc. shall be 4-20 mA.

Discrete outputs (on/off) of all electromechanical equipment such as flow switches, pressure switches, level switches, valve position switches, relay circuits, etc. and of all electronic switching devices such as electronic level and limit switches, etc. shall be voltage-free contacts rated for at least 1 A at 250V AC and the voltages/currents shall generally be shown on the drawings (bill of materials). In general, the above will be 24V DC.

8.1.3.2 Power Supply Units - DC Power Supply

Instruments shall be of the "two wire" type deriving electrical power from the loop 24 VDC supply.

The DC supply available within the Plant shall be 24 VDC ± 10%.

8.1.3.3 Power Supply Units - AC Power Supply

Where an instrument cannot be supplied with 24V DC and a separate power supply is required, integral power supplies shall be provided to allow reliable operation directly from a UPS backed power supply.

Surge reduction filters shall be provided to protect all instrument power supplies against input over-voltage and mains borne sags, surges and impulses originating from lightning, switching operations or other causes. Common and normal mode noise rejection and isolation characteristics of the supplies will be adequate to allow for reliable operation. Voltage and frequency regulation shall be provided as necessary.

Instruments shall be powered from a UPS via a UPS Distribution Board for 240V AC instruments or 24V DC power supply and 24V DC circuit breaker load centre in the MCC for 24V DC instruments. All instruments located externally to a facility (e.g. located outside of a building) requiring a separate power supply (i.e. 4 wire instruments) shall have its power supply surge protected at each end.

8.1.3.4 PLC I/O and Instrument Surge Arresters

Comprehensive surge protection shall be provided for all low voltage and instrument cabling entering or leaving a building.

In particular, all 4 – 20 mA instrument loops shall be provided with arrestors at the instrument, converter and the PLC terminals. The arrestor shall be a self-resetting single-phase 20 kA unit with a clamp voltage of not in excess of 36 V with a maximum line current of 1500 mA rms.

All 24 VDC, status and indication circuits shall be fitted with arrestors at the switchboard terminals at each PLC slot or remote IO module only. Surge protection for digital IO is not required on the field device.

The arrestor shall be suitable for balanced and non-balanced circuits, a surge current up to 10 kA and a clamp voltage of not in excess of 36V.

All field communications devices shall incorporate surge protection.

8.1.4 Field instrumentation

8.1.4.1 Transmitter enclosures

All electrical components of field instruments shall be contained in hose proof and dustproof stainless steel or marine grade aluminium enclosures to IP65. Tapped cable entries shall be provided to accept cable glands. All gland entries not used shall be suitably sealed.

8.1.4.2 Indicators

Indicators shall be of the digital display type of flush mounting pattern utilising a LCD.

Indicators shall be selected to allow for accurate reading at a distance of 3 m from the unit in the installed location. Indicators shall be scaled in engineering units as defined in instrument data sheets.

Indicators shall include continuously variable span and zero adjustments. Adjustment shall be provided via inconspicuous front panel controls.

Each indicator shall accept a 4-20 mA signal input.

Indicators shall be mounted in enclosures as specified in Section 8.1.4.1.

8.1.4.3 Mounting of instruments and enclosures

Mounting methods shall at all times be suitable for the mass and duty of the device and the environment into which it is to be mounted. Instruments shall be easily accessible and maintainable in position.

Sunshades shall be provided for all field instruments to protect against mechanical damage, solar heating and UV damage where exposed to these conditions in the installed position.

Instruments and enclosures should only be located in readily accessible locations without the need to enter confined spaces and taking into consideration environmental requirements such as hydrogen sulphide corrosion.

Where instruments use transmitters that are separate from the sensor, and the transmitters are not housed in enclosures, the transmitter shall be mounted on a stainless steel bracket with a sunshade for protection against mechanical damage, solar heating and UV damage.

Indicators and transmitters with integral displays shall be mounted to avoid exposure of the LCDs and membrane keypads to direct sunlight. Orientation of the displays and indicators shall be facing south or east. Where this is not practicable approval is required from the Engineering personnel for the most suitable installation location.

Displays and indicators shall be mounted at a height of between 500 mm and 1600 mm above the surrounding finished ground level.

Where instruments are mounted in or extend into tanks or other vessels, the instrument shall be mounted and the cables shall be long enough to enable ease of removal for cleaning, operation and maintenance requirements. Brackets used shall preferably be proprietary in nature and will not be put under undue stress from normal operation due to the weight of the instrument or the process it is measuring.

No instrument shall be direct buried. If an instrument is required to be installed below ground then a suitably designed and accessible pit shall be provided. The requirements of Section 5.5 also apply to instrumentation installed in pits especially in regards to drainage.

8.2. Flow

8.2.1 General

Instruments used for flow measurement include:

- Magflow meters
- Flow switches
- Differential pressure
- Mass flow
- Pitot Tubes/Rotameter.

8.2.2 Magflow meters

Magnetic flow meters may be used in water service. Magnetic flow meter excitation shall be 24V DC. The flow transmitter may be integral to the meter body, but preferably remotely mounted to enable easy viewing in the field.

An earthing ring with protecting edge shall be supplied by the meter vendor. The electrodes shall be fixed type. The electrode material of construction shall be 316 SS, unless other material is required for corrosion resistance (e.g. Hastelloy C).

The sensor shall be suitably lined to resist wear and corrosion. Where negative pressure (i.e. vacuum) is possible, the lining may be omitted.

The signal cables between the sensor and the transmitter shall be screened.

'Smart' communications to the transmitter shall allow remote interrogation, diagnostics and reconfiguration.

The transmitter shall incorporate all range settings, zero settings and necessary controls and shall produce a linear 4-20 mA flow signal. The transmitter shall have a digital display to show the flow rate and total flow volume. The transmitter 4-20 mA flow signal shall have a measurement accuracy not exceeding ± 0.25 % of measured flow for velocities ± 0.5 m/s.

The flow meters shall have the capability for on-site verification.

Earthing rings shall be installed and correctly connected for all installation conditions.

Above ground installations of the flowmeter tubes are preferred where practical and where the site/compound is secure.

Where a flowmeter is to be installed in a below ground pit the pit shall have a sump well. Where gravity drainage is not feasible, a sump pump shall be installed. The requirements of Section 5.5 shall be adhered to in regards to drainage.

All flowmeter pits shall have a minimum of two (2) 50mm conduits being for power and instrumentation.

Manufacturer's factory calibration certificate for the flowmeter shall be provided to ensure accuracy and other requirements are met.

8.2.3 Flow switches

Flow detection on hydraulic systems shall be non-insertion type instruments; paddle type flow switches shall not be used.

8.2.4 Differential pressure

The material for orifice plates should be compatible with the fluid handled. The preferred material is type 316 Stainless Steel.

For liquids with entrained solids, eccentric orifice plates may be used subject to the approval of the Unitywater Engineering personnel. Alternate design (multi-hole) orifice plates which may reduce the straight run piping requirements may be used subject to the approval of the Unitywater Engineering personnel. No drain or weep holes shall be made in any flow orifice plate.

Use of straightening vanes shall be subject to the approval of Unitywater.

Square root extraction shall be performed in the transmitter.

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

- Normal flow rate shall be between 70 % and 80 % of the full scale flow provided that the anticipated minimum and maximum flow rates will be between 33 % and 95 % of the full scale flow and the accuracy of the transmitter is at least 0.2 % of the calibrated span.
- Where the rangeability required is between 33 % and 95 %, a single transmitter may be used.
- Where the rangeability required is greater than 33 % and 95 %, dual transmitters may be required and shall be submitted for approval.
- Where a differential pressure transmitter is used as a flow input to safety system, the transmitter range shall be such that the trip point is at least 33% of the full scale calibrated span.

Orifice plate Beta ratios (orifice diameter/pipe inside diameter) shall be limited to values between 0.3 and 0.7.

The preferred DP cell range is 25 kPa. Common alternatives are 10 kPa and 50 kPa and shall be subject to Unitywater Engineering personnel approval.

Orifice size, flange size, flange rating and instrument number shall be stamped on the upstream side of each orifice plate and shall be visible when the orifice plate is installed.

Orifice plate flow meter flanges shall have the following requirements:

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

Differential pressure (DP) transmitters shall be remote mounted to minimise or eliminate vibration issues but lengths of impulse piping should be kept to a minimum. The following guidelines may be used to determine limitations for direct mounting of transmitters:

- DP transmitters to be direct mounted in lagged service up to process temperature of 250°C.
- DP transmitters installed on process temperatures above 250° C will require remote seals of fill fluids suitable for such temperatures.
- DP transmitters to be direct mounted in flushed services for process temperatures of flush fluid within the Vendor supplied temperature limits for the transmitter fill fluid (no dead legs exist for these installations and therefore no cooling).

For installations in vertical pipelines the direction of flow shall be downwards for wet gas or saturated steam and upwards for liquids.

Upstream straight length requirements shall be in accordance with the manufacturer's requirements.

DP transmitters in gas service shall be mounted above the flow element.

DP transmitters in liquid service shall be mounted below the flow element.

The static pressure range and maximum working pressure of the pressure transmitter shall be suitable for the application. Positive over-range protection shall be provided.

The output signal shall be proportional to the calculated flow rate.

The static pressure range and maximum working pressure of the pressure transmitter shall be suitable for the application. Positive over-range protection shall be provided.

The transmitter shall include independently adjustable zero and span adjustment and adjustable internal signal damping. A digital display shall be included at the transmitter.

The differential pressure transmitter shall be supplied with a three valve manifold.

8.2.5 Mass flow

For liquid mass flow applications, Coriolis type mass flowmeters are the preferred choice. Straight tube type Coriolis mass flowmeters are preferred over bent tube type Coriolis mass flowmeters. Coriolis mass flowmeters shall have a 316 SS sensor unless process requirements dictate the requirement for Hastelloy C.

8.2.6 Rotameter/pitot tube

Averaging pitot tubes or thermal dispersion meters may be used for some applications with the Engineer's approval. Installation of averaging pitot tubes shall be such that they are removable on line, unless indicated otherwise.

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

Each Rotameter shall be of the tapered tube and float type, of straight through construction with flanged or threaded end connections as required.

The rotameters shall have tempered glass tubes, stainless steel end fittings and stainless steel floats. The rotameters shall incorporate a metering tube that can be removed and cleaned without removing the meter body from the line.

The rotameters shall be selected to suit the range for each individual application and shall be accurate to ± 2 % of full scale over a minimum turndown ratio of 10:1. The rotameters shall be fitted with a direct reading scale, nominally 250 mm long and scaled in litres/second as appropriate for the flow ranges of each application.

Where switching is required in a rotameter, a magnetically activated switch arrangement providing a voltage free contact shall be provided for 2 wire connection.

Positive displacement flowmeters may be used for local flow indication/totalising in non-critical process lines (e.g. utilities).

8.3. Level

8.3.1 General

Where more than one level transmitter is installed on a vessel, both shall be calibrated to the same operating span and level wherever possible. Where level gauges (magnetic or glass) are installed alongside other level instrumentation the level gauge span shall match or exceed that of the vessel operating range.

Where vessels have both level instruments in both control and shutdown applications, different types of level transmitters shall be installed to reduce common mode failures. For continuous level measurement, the following level transmitter types are the preferred choice:

- Magnetic follower style gauges with magneto restrictive level transmitters for use in shutdown applications.
- Ultrasonic or Hydrostatic level transmitters for use in control applications. Guided wave radar level transmitters may also be considered.

The lower connection to a vessel should not be taken from the bottom of the vessel to minimise fouling of tappings and ensure full range of measurement. Where bottom of vessel nozzle connections cannot be avoided, an up-stand in the vessel should be installed.

All continuous level measurement instruments shall be provided with a means of in-situ calibration and testing.

Level bridles and gauges shall be supplied with vent and drain valves that comply with the relevant Unitywater isolation standards.

On liquid/liquid interface service the vessel top instrument connection shall be submerged in the lower density fluid under all normal operating conditions.

8.3.2 Level instruments

Level instrument types are shown below:

- Ultrasonic
- Hydrostatic
- Radar
- Laser
- Differential pressure
- Level Sensors:
  - Capacitance
  - Conductivity (multi or single point)
- Level Switches:
  - Floats
  - Paddle
  - Capacitive
  - Vibrating.

8.3.3 Ultrasonic level transmitter

Provision shall be made at the transmitter for independently adjustable span and zero adjustment and adjustable internal damping. The transmitter shall incorporate a LCD. Accuracy shall not be less than ± 0.25 % of maximum range or 6 mm whichever is the greater.

Differential ultrasonic level instruments specifications shall include those given for ultrasonic level instruments above. Two sensors shall connect into the one transmitter and the 4-20 mA level output signal shall be calculated by the transmitter as the difference in level detected by the two sensors.

8.3.4 Hydrostatic type level transmitters

Each electronic hydrostatic level transmitter shall provide measurement referenced to atmosphere either using a capillary tube connected to the sensor and vented to atmosphere at a connection box or absolute pressure measurement at the sensor and atmospheric pressure measurement at the transmitter.

The range and maximum working pressure of the transmitter shall be suitable for the application.

The transmitter shall include temperature compensation and adjustable internal signal damping. Accuracy shall not exceed 0.2 % of range at a maximum turndown of 1:10.

8.3.5 Radar

Section reserved for future use.

8.3.6 Laser

Section reserved for future use.

8.3.7 Differential pressure level

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

8.3.8 Level sensors

8.3.8.1 Capacitance type

Each capacitance level measurement system shall consist of an electrode (or probe), an electronic unit in the head of the probe and a signal converter unit. An earthing reference shall also be supplied if necessary.

The electronic unit shall operate at a frequency suitable for the application, shall be mounted in the head of the probe and shall be encapsulated in an inherently non-corrosive, durable material to at least electrical enclosure class IP65.

Each electronic signal converter unit shall generate an isolated 4-20 mA DC current analogue output corresponding to the level and shall incorporate provision for continuous adjustment for both measurement span and zero. The signal converter shall incorporate an analogue or LED indicator with an accuracy of better than ± 5 % of full scale. The power, frequency and pulse rate shall be suitable for this application.

8.3.8.2 Level sensors (multiple/single point conductivity)

Probes shall be cable suspended PVC tube body with stainless steel sensors located at 150 mm increments along the height of the probe. Each sensor shall be wired out to allow connection of all or any level to extra low voltage control equipment. Each cable core shall be numbered. The cable sheath, probe body and sensors shall be entirely suitable for long term operation in the environment in which it shall be installed. The probe shall be fitted with cable of sufficient length to terminate in the switchboard without joints, suspended from a purpose built stainless steel bracket incorporating a flexible probe cleaner.

The pump controller shall operate in conjunction with the conductivity level probe. The controller shall be self-contained to control pump(s) and alarms, and shall feature

- incremental bar graph indication of well/reservoir/pit level
- selectable levels for each pump start, stop, and alarm
- selection of pumps to duty, standby or alternating
- selection of fill or empty modes.

The connection to the level probe shall include internal or external lightning protection as required.

8.3.9 Level switches

8.3.9.1 Level switches (Float Type I)

Each level switch shall be of the encapsulated, immersible, mechanical switch type. The switches shall not contain mercury. Each shall be supplied complete with a sufficient length of heavy duty flexible cable to provide a generous allowance for adjustment of the operating level.

All wetted materials shall be inherently non corrosive material and entirely suitable for the application.

8.3.9.2 Level switches (Float Type II)

Each level switch shall be of the float-activated bulkhead mounting type.

Float, stem and other wetted materials shall be constructed from inherently non corrosive material and entirely suitable for the application.

Each level switch shall be provided with a voltage free, changeover contact.

8.3.9.3 Level switches (Paddle Type)

Level switches for sensing level of non-liquid bulk materials shall be of the motor driven rotating paddle type. The detection of material is achieved by a rotating paddle with the control signal changing when material impedes rotation of the paddle.

Shafts and paddles shall be constructed from materials which are corrosion resistant to the material being sensed.

The number and size of paddle vanes shall be selected as appropriate for the density of materials sensed.

The paddle switch sensing unit shall include controls to ensure that when material impedes the rotation of the paddle that all moving parts are stationary and no wear takes place.

Each paddle switch shall satisfy enclosure class IP65 or better and shall be provided with a voltage free, changeover contact output.

8.3.9.4 Level switches (Capacitive)

Each capacitive level switch shall consist of an electrode (or probe), and an electronic signal converter unit. An earthing electrode (or probe) shall be provided as necessary for correct operation.

The electronic signal converter shall have a sensitivity suitable for the application.

Each electrode (or probe) and all other wetted materials shall be suitable for the application.

Where the electronic signal converter is mounted in the head of the probe it shall be encapsulated in an inherently non-corrosive, durable material to at least electrical enclosure class IP65.

Each electronic signal converter shall satisfy enclosure class IP65 or better and shall be provided with a voltage free, changeover contact output.

8.3.9.5 Level switches (vibrating)

Each vibrating level switch shall consist of a sensor and an isolating electronic switching unit.

In addition to a true level alarm condition, the electronic switching unit shall activate the alarm contact upon detection of a damaged sensor and for a short time on power-up. Switching time shall not exceed 1 second. Accuracy of the combined unit shall not exceed 1 mm.

8.3.9.6 Float devices

Float devices may only be installed on specific non-critical applications where other measurement techniques are unsuitable, for example on sump level.

8.3.10 Guided wave radar

Radar level measurement for process vessels shall be considered where the relative dielectric constant of the measured medium is suitable for this technology.

Radar transmitters shall only be installed in a manner that allows their total removal on line without impact on the process. For this reason, radar transmitter installation will normally be via an external cage with isolation valves to the main vessel. Installed in this way, guided wave technology is the preferred option.

Radar level measurement shall not be used for interface applications unless specifically approved by Unitywater Engineering Personnel. Installation of radar element shall meet manufacturer's criteria for distance from sidewalls and internal obstructions.

8.3.11 Level bridles

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

The same level bridle shall not be used for site control system and for dedicated safety level instruments. Where several level instruments are required on a vessel, a separate bridle shall be used by each level instrument.

Bridle process interfaces shall be via DN50 flanges having a minimum rating of ASME class 150. Level bridle material of construction shall be 316 SS unless another material is required for corrosion resistance.

Bridles shall be equipped with DN20 (minimum) vent and drain valves. Where required as per process design shown on the P&IDs, drain valves shall be piped into the facility drain system.

No bridle may connect across more than two adjacent phases on a three-phase vessel. In this event, a third balancing connection is required to accommodate the middle phase.

Careful consideration must be given to the placement of the taps in relation to the normal location and range of the interface. In some cases, additional taps may be required to ensure continuous and correct measurement of the interface.

Bridles shall not be used under the following circumstances:

- In low temperature (< 0 °C) service.
- On packed sections, across filter pads, demister pads, in viscous service and in applications where materials being handled contain high concentrations of solids.

No vertical dog-legs will be allowed in making level connections to bridles.

8.3.12 Level gauges

8.3.12.1 Magnetic level gauges

Magnetic level gauges are preferred for many applications but special consideration is required as:

- These gauges are sensitive to low Specific Gravity (SG) applications. Actual operating SG is to be verified prior to purchase with laboratory testing where possible.
- Floats are very susceptible to over pressure. The maximum pressure (relief case) of the vessel shall be considered.
- They may not be suitable for interface applications where the operator is required to view the liquid.

When magnetic level devices with 4-20 mA transmission are used, consideration during design shall be given to the impact of “loss of float” by the analogue transmitter. The data sheet shall specify the safety requirement for “loss of float” by the transmitter (i.e. signal fail high or low).

Level transmitters mounted on magnetic level gauges can only be used in clean, non-solidifying, non-crust forming services. In dirty, solidifying, crust forming services the preferred instrument for level indication and control shall be non-contact radar transmitters. Where dielectric limitations preclude the use of this technology, capillary type seal DP transmitters shall be considered but require the approval of Unitywater Engineering Personnel.

The following notes apply if the gauge is fitted with a level transmitter:

- The level transmitter should be fitted to the gauge by the Vendor.
- Transmitter shall be perfectly parallel and in contact with the float chamber over its entire length.
- Sufficient cable length shall be provided to allow the adjustment of height of the transmitter of at least ±30% without disconnecting terminations or unclipping cable from supports.
- The scale on the level glass shall be marked, as a minimum, at 0 %, 50 % and 100 % corresponding to the transmitter output.

8.3.12.2 Level gauge glasses

Gauge glasses in hydrocarbon service shall be high pressure, flat glass type made up of individual 350 mm nominal length sections connected by piping. Maximum length of gauge glass assembly shall be 3000 mm.

If the length is over 1500 mm an intermediate support shall be provided. Block valves shall be provided in addition to the offset-type cocks. Excess flow type isolation cocks shall be fitted as standard.

Reflex type gauges are only suitable for clean liquid services. Transparent sight glasses shall be used for other services.

Integral illuminators shall only be fitted to transparent sight glasses where the process fluid is such, that illumination is required for sighting of the level. No vertical dog-legs will be allowed in making level connections to gauge glasses.

Gauge glass shall be of such quality that it will break with an interlocking crystalline fracture without loose, flying particles (normally referred to as tempered glass). Gauge glasses shall be equipped with DN20 vent and drain valves. Drain valves shall be piped into the facility drain system.

8.4. Pressure

8.4.1 General

Instruments used for pressure measurement include:

- Pressure transmitter
- Pressure switch
- Pressure gauge.

Pressure instruments may be required in the following applications:

- Pipe pressure
- Vessel pressure.

Pressure elements shall be specified such that the steady normal operating pressure does not exceed 75% of the maximum range. Pressure elements shall be such that the process pressure does not exceed the maximum rating of the element. If the process pressure can exceed the instrument rating pressure then an adequate overpressure protection technique shall be employed. For each application, Unitywater Engineering Personnel shall approve the technique used.

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

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

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

8.4.2 Pressure transmitters

The transmitter shall include independently adjustable zero and span adjustment and adjustable internal signal damping. Two valve manifolds shall be supplied with each gauge pressure transmitter. Three valve manifolds shall be supplied with each differential pressure transmitter.

8.4.3 Pressure switches

The adjustable set point range shall be such that the noted setpoint falls between 30 and 70% of the adjustable range. The switch shall be of the automatic reset type with an adjustable switching differential.

8.4.4 Pressure gauges

Pressure gauges shall have the following features:

- ½" NPTM bottom entry
- 316 SS movement
- 100 mm diameter dial
- Weather proof 316 SS Case (IP65 rating or better)
- Solid front
- Shatter proof glass
- Glycerine filled
- Blow out back (or pressure relief vent for the cases)
- White dial with black lettering and black pointer.

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

Pressure gauges shall be selected so that the normal operating pressure is 50-70% of the full range of the gauge.

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

Where pipework is subject to mechanical vibration, pressure gauges shall be mounted adjacent to the pipework and connected to the pipework tapping via pipework. Where specified or as otherwise required where gauges are subject to a process medium of high temperature that would affect operation, a siphon shall be provided to isolate the medium from direct contact with the gauge.

Pressure gauges shall be accurate to ±1% of full scale.

8.5. Analyser

8.5.1 General

In general, analyser outputs shall be 4-20 mA loops with 'Smart' communications protocols as described in Section 8.1.1.

Common hardware alarms for each analyser to be provided and alarmed to the Plant Control System.

Liquid samples shall be returned to process.

Analysers are to be mounted as close as practical to the sample point in a weatherproof naturally vented shelter or prefabricated analyser house subject to Company approval.

Local flow, pressure and temperature indications are to be provided on analyser sample handling systems.

Analysers shall have power isolators mounted adjacent to each analyser in the field.

Fast loops are to be provided for all liquid analysers. Local flow and pressure indication shall be provided on all fast loops. The analyser shall have remote shutdown and start-up wired from the PCS so that the operator can take the analyser out of service during unit upsets etc.

8.5.2 Chlorine

Chlorine analysers shall utilise amperometric measurement cells and shall incorporate temperature compensation and self-cleaning of the measuring cells.

'Smart' communications to the transmitter shall allow remote interrogation, diagnostics and reconfiguration.

The transmitter shall incorporate all range settings, zero settings and necessary controls and shall produce a linear signal. The transmitter shall have a digital display to show the chlorine residual level and any fault diagnostics information.

8.5.3 pH measurement

The equipment for the measurement of pH shall include either single combination electrodes or discrete measurement and reference electrodes.

The reference electrode shall be sealed, gel filled and non-flowing with a ceramic or similar junction that resists fouling.

Each pH electrode housing shall comply with the requirements of enclosure class IP68 (in accordance with AS 60529).

Automatic temperature compensation shall be provided for each pH measurement. The pH electrodes shall be equipped with an automatic electrode cleaning device to reduce routine manual cleaning.

The cleaning method utilised shall be entirely suitable for the process fluid monitored.

The pH electrode housing shall be manufactured from glass fibre reinforced polypropylene or similar.

An indicator should be provided as part of the unit to display the output on a scale directly calibrated in pH units, to accuracy better than ±2 % of span.

The transmitter shall include facilities for manual range changing, zero and span adjustment and for any other adjustment necessary for accurate calibration of the instrument.

All input circuits shall be isolated from the mains supply and output circuits.

The transmitter shall include functionality for sensor life and condition diagnostics.

8.5.4 Turbidity

Turbidity analysers shall utilise the 90° scattered light principle of operation.

The sensor and/or sensor housing shall incorporate measures to prevent or remove material deposits from the light source and the sensing windows.

The sensor arrangement shall also incorporate features to prevent air bubbles from interfering with measurement. Where an auto-cleaning function is incorporated this shall be configurable from the transmitter.

The transmitter shall incorporate all range settings, zero settings and necessary controls and shall produce a linear 4-20 mA turbidity signal.

The transmitter shall have a digital display to show the turbidity level. Where dry secondary calibration standards hardware is available for calibration, these shall be provided with the turbidity transmitter.

8.5.5 Ammonia

Ammonia analysers shall utilise colorimetric detection and shall incorporate temperature control of the measuring cells.

Calibration and cleaning shall be configurable automatic functions of the analyser. Manually initiated grab sample and analysis shall be included as a standard function.

'Smart' communications to the transmitter shall allow remote interrogation, diagnostics and reconfiguration.

8.5.6 Nitrate

Depending on process requirements, nitrate measurement shall be performed by one of the methods described below. Both methods utilise light absorption techniques.

8.5.6.1 Submersible sensor probe

The Nitrate analyser shall utilise the UV light absorption method for Nitrate measurement.

The Nitrate measurement system shall comprise (as a minimum):

- Submersible sensor with wiper cleaning system
- Mounting hardware
- Connection cable
- Transmitter.

The transmitter shall incorporate all range settings, zero settings and necessary controls and shall produce a linear signal.

The transmitter shall have a digital display to show the Nitrate level and fault diagnostic information.

The following spares shall be supplied and shall be suitably packaged for long term storage in a coastal environment:

Wiper blades of a quantity that will supply maintenance requirements for the period of two years.

8.5.6.2 In-line sampling analyser

The Nitrate analyser shall use a light absorption method and shall include compensation for sample turbidity and ageing of the photometer detector light source.

The Nitrate analyser shall incorporate temperature control of the processed sample into the measurement photometer chamber.

Calibration shall be a configurable automatic function, including flushing sequence, of the analyser.

'Smart' communications to the transmitter shall allow remote interrogation, diagnostics and reconfiguration.

8.5.7 Dissolved oxygen

Dissolved Oxygen analysers shall use either the Clark Principle or Luminescence Quenching method for measurement. Dissolved Oxygen sensors shall be provided with temperature compensation.

Dissolved Oxygen sensors shall have a measurement range of up to 20 mg/L with an accuracy of at least ±2 % across the measurement range. The system shall also feature auto-cleaning and auto-calibrate functions.

The Dissolved Oxygen instrument shall be supplied with:

- Submersible sensor with auto-cleaning system
- Mounting hardware (arm or float)
- Sensor cable
- Transmitter.

'Smart' communications to the transmitter shall allow remote interrogation, diagnostics and reconfiguration.

8.5.8 Conductivity

The conductivity probe shall consist of a primary sensor and a signal transmitter. The sensor shall be housed in one common body (minimum IP67 in accordance with AS 60529), rapid and easy servicing complete with integral cable for connection to the signal transmitter.

The conductivity probe may be contacting type or toroidal. The toroidal type conductivity sensor shall be supplied with a 1½" NPT process connection. The contacting conductivity sensor shall be supplied with a ¾" NPT process connection.

The sensor's electrodes shall be stainless steel and insulators of Tefzel and Viton, or better. The transmitter shall incorporate a built-in digital display to for the conductivity value of the measured sample and with built-in temperature compensator.

The primary sensor shall designed to continuously measure the conductivity value (between 0 and 2000 µS/cm) over a temperature range of 20 to 50 °C. The accuracy of the conductivity analyser shall be 0.5% of the full-scale reading at 25 °C with a repeatability of +0.01 % or better. The entire system shall have automatic temperature compensation.

Conversion of the conductivity measurement to the corresponding Total Dissolved Solids (TDS) reading shall be performed in the site control system.

8.5.9 Density measurement (Nucelonic)

The density sensor shall be of the nonintrusive type utilising a radioisotope and manual shutter on the source housing clamped to the outside of the pipework. A separate transmitter shall be supplied with the density sensor.

The sensor shall be provided with any proprietary leads and cables for connection between the sensor and transmitter.

The transmitter shall have a typical precision of 2 g/L.

Where possible the density sensor shall be mounted with the material flowing in a vertical fashion so as to minimise errors.

Where the sensor cannot be mounted as preferred, the sensor shall be mounted with the transmitter and receiver orientated in a vertical fashion on pipework with a horizontal material flow. It shall be installed as per the manufacturer's recommendations.

8.5.10 Ferrous Chloride

Section reserved for future use.

8.5.11 Carbon Dioxide (CO_2)

Not used in WWTP.

8.6. Temperature

8.6.1 General

All temperature instruments (dial thermometers, thermocouples and RTDs) shall be installed in flanged thermowells. Exceptions (e.g., skin temperatures) shall be approved by Unitywater Engineering Personnel.

Temperature instruments shall be ranged to include start-up and abnormal operating conditions.

8.6.2 Dial thermometers

Field temperature indicators (dial thermometers) shall be of the bimetallic type, with a 100 mm dial size unless otherwise specified. Dial thermometers shall have adjustable every-angle heads. The element diameter is nominally 6 mm with a ½" NPTM connection.

In applications where bi-metallic thermometers are not suitable, filled systems may be used. The preferred materials for filled systems are 316 SS wetted parts with gas fill. All such applications are to be approved by the Principal's Representative. Where required for readability or protection from vibration, indicators shall utilise a fully compensated filled system with a 316 SS armoured capillary tube and with a remote reading dial.

Mercury thermometers shall not be used.

Where possible, dial thermometers shall comply with the standard manufacturer's ranges.

8.6.3 Resistance temperature detectors

In general, Resistance Temperature Detectors (RTDs) shall be utilised for temperature measurement.

Each resistance thermometer shall include a 3-wire platinum RTD complying with IEC 60751 (R_o = 100 Ω). 4-wire RTDs may be used where required. 2-wire RTDs shall not be used. The sensing element shall be sealed in a ceramic former and enclosed in a stainless steel sheath. Sensing currents of up to 10 mA shall not have a significant effect on accuracy.

Installation of the RTD, including wiring to the associated resistance to current converter, shall comply with BS 1041-3. A 3-wire circuit shall be used between each RTD and the transmitter. The transmitter shall be located in the RTD connector head.

Resistance to current converters shall be of the "two wire" type deriving electrical power from the loop 24 Vdc supply. Transmitters shall include continuously variable span and zero. The output shall be a 4-20 mA signal linear with respect to temperature.

Accuracy shall be ±0.5% of span or better.

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

Where RTDs are not suitable, i.e., due to required measuring range, chromelalumel (Type K) thermocouples may be used.

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

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

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

8.6.4 Thermowells

Unless otherwise approved by Unitywater, thermowells shall be constructed from barstock of 316 SS material (flanges can be welded on). Where fabricated wells are allowed, weld and stress relieving procedures shall be provided

For vessels, thermowell flanged connections shall have a minimum rating of ASME class 300. For piping, ASME class 150 flanged thermowells may be used in ASME class 150 pipework.

Thermowells shall be installed in sections of pipe with a minimum diameter of DN100. Where thermowells are required to be installed in pipework of diameter DN80 or smaller, reducers shall be installed either side of the thermowell to increase the pipe diameter to DN100.

Thermowells shall be of the tapered shank design and have a DN50 flanged process connection.

All thermowells shall be supplied with material certification, pressure test certificate and full dye penetration certificate. Thermowell NDT shall be in accordance with ASME 5 or AS 2062 with certificates issued by a NATA certified authority.

Thermowells shall be uniquely tagged. “U” length shall be permanently engraved on the thermowell flange. Thermowell shank tip position shall be in within ±10% of the pipe centreline. A process connection plug and chain shall only be supplied for wells designated for test insertion usages.

Thermowell design calculations in accordance with ASME PTC 19.3 TW-2010 shall be provided for all thermowells installed in flowing lines.

All thermowells shall be assessed for resonance effects via wake frequency calculations - worst case wake frequencies shall be < 0.8 of the calculated wake frequency.

Bending stress calculations shall be provided for all thermowells.

Insertion lengths shall be supplied as indicated on the data sheets.

8.6.5 Temperature switches

Temperature switches (thermostats) shall be Danfoss UT/KP. The switches shall not contain mercury.

Where required a copper tube protected capillary shall be provided for connecting the switch mechanism to the remote bulb installation.

A calibrated adjustment for the set point shall be provided. The adjustable set point range shall be such that the noted set point falls between 30 and 70 % of the adjustable range. The switch shall be of the automatic reset type with an adjustable switching differential (except where noted).

8.7. Proximity sensors

Proximity sensors shall be 3 wire PNP inductive devices. Proximity sensors shall withstand reverse polarity connections and shall incorporate short circuit protection.

9. Motor starters

9.1. General requirements

The following starter types shall be used for three-phase motors. The motor size limit is also shown:

- Direct Online (DOL) – 0-11kW motors
- Variable Speed Drive (VSD) – any size motor may use VSD however it must be used for motors above 11kW.

Motor starters shall be mounted in accordance with the manufacturer's requirements with regards to space around the starter.

Where motors starters are mounted within a switchboard/enclosure, fan ventilated enclosures may be required for high heat loads. Fan ventilated enclosures shall operate under positive pressure. Replaceable filters shall be provided to prevent dust ingress. The switchboard/enclosure still needs to meet the requirements of Section 3.3 and Section 4.

Motor starters shall have been tested by a recognised testing authority for compliance with AS/NZS IEC 60947.4.1. If this testing was not carried out within Australia, then a Certificate of Approval shall be provided from an approved Australian Electrical Distribution Authority.

Motor starters shall have the following classification characteristics in accordance with AS/NZS IEC 60947.4.1:

Table 13: Motor Starter Characteristics

Contactor Characteristics	Required Standard
Rated Frequency	50 Hz
Rated Voltage	415 V AC
Rated Continuous Current	Rating shown on design drawing or in Schedule of Technical Requirements
No. of Poles	3
No. of Phases	3
Interrupting Medium	Air
Control Method	Electrical
Mounting	Fixed
Type of Release	Undervoltage
Rated Duty	Uninterrupted
Rated Operational Current	Motor full load current plus 20%
Utilisation Category	AC3
Mechanical Endurance	10 million operations
Electrical Endurance	1 million operations

Contactor Characteristics	Required Standard
Coordination with protective device	Type “2”
Rated Control Supply Voltage	24V DC
Auxiliary Contacts	2 N/O and 2 N/C (minimum)

Contactors shall be of the moulded block type with modular design suitable for vertical mounting.

Coils shall be continuously rated to operate at 24V 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.

Motor contactors shall be equipped with electronic overload.

Each contactor shall have a means of mechanical indication to show when it is energised.

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

Mounting screws shall be accessible from the front.

DOL starters may be used for motors 11kW and below. Motor starters above 11kW must be soft started with a VSD.

Each motor starters shall be dedicated to one motor only.

9.2. Electronic motor protection relays/DOL

All electronic motor protection relays shall monitor both voltage and current.

All DOL motors shall be protected by electronic motor protection relays incorporating at least the following features:

- overcurrent protection
- overvoltage/undervoltage protection
- simulated motor thermal image based on phase currents
- integral thermistor protection
- phase failure and asymmetry protection
- individual heating and cooling time constants for the motor thermal image
- single phasing protection
- ground fault protection
- stall protection
- incorrect phase sequence protection and adjustable underload protection.

An Operator Interface Panel (OIP) shall be provided and installed on the door of the motor starter.

All electronic motor protection relays shall be able to provide at least the following on the OIP and through SCADA:

- Energy consumed (kWh)
- Power (kW)
- Motor Current
- Drive Status (Run, Stop, Fault)
- Cause of a trip.

The relay shall be complete with appropriate data communications functionality dependent upon site PLC Architecture used.

9.3. Soft starters

Soft starters are not allowed.

9.4. Variable Speed Drive

9.4.1 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.

The VSD shall be specifically designed to operate a standard 415V AC squirrel cage induction motor as per the requirement of Section 10.

VSD shall be installed for all installations above 11kW.

VSD shall generally be mounted on the switchroom wall. VSD that are mounted on motors will not be accepted.

The VSD shall feature:

- independently adjustable maximum and minimum speed
- at least two jump frequencies
- automatic restart after momentary power failure
- torque limiting feature to prevent tripping due to transient overcurrent
- slip compensation
- adjustable acceleration and deceleration times with settings up to 1200 s
- automatic reset of selected fault conditions
- all drive parameters to be stored in non-volatile memory
- drive parameters to be uploaded and downloaded via integral communications port
- comprehensive drive diagnostics and multilevel fault finding.

The drive installed rating shall be on the basis of the motor nameplate full load current with a suitable de-rating for ambient temperature, enclosure, ventilation, with due regard to the characteristics of the driven equipment. The installed rating of the equipment shall be a minimum of 110% of Maximum Continuous Rated, and be entirely suitable for repeated overloads of 120% for 60 seconds and 150% for 6 seconds at not more than 6 repetitions per hour.

VSD's shall have upstream protection devices installed, as per the VSD manufacturer's recommendations and the requirements of AS/NZS 3000 especially in regards to earth leakage.

The output waveform of the VSD shall be such that motor derating of a standard AC induction motor is not required. The VSD shall be capable of starting into a rotating motor, without tripping.

The VSD shall be provided with adjustable starting torque for hard to start loads, and a selection of basic V/Hz relationships to ensure optimum operation of the motor and VSD combination.

A motor fed from a VSD shall have a shielded and appropriately earthed cable suitable for VSD operation as per the requirements of Section 5.4.

All settings within the VFD shall be recorded and provided to Unitywater as part of handover documentation. Any additional software and/specialist cables shall also be provided.

9.4.2 Internal to MCC

Where VSD are installed internal to the switchboard, the switchboard shall be provided with adequate ventilation to ensure internal temperature does not exceed the VSD recommended maximum temperature.

If additional cooling is required the consideration should be given to mount the VSD externally to the MCC. Further details for additional cooling are outlined in Section 9.1.

VSD's installed within a MCC shall have IP rating of at least IP2x.

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.

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.

9.4.3 External to MCC

VSD over 60kW must be mounted externally to the switchboard.

All VSD's shall be rated to IP42, where mounted on the wall of the switchroom. Motor, control and Thermistor/RTD cables shall be connected direct to the wall mounted VSD.

VSDs that are mounted external to a switchboard are to be mounted neatly on a wall and placed such that the physical size of the drives decreases along the wall. Where VSDs are too large to mount on the wall, floor mounted, dead front enclosures shall be used. Floor-mounted VSD enclosures shall be in accordance with Section 4.

Where a choke/output filter or the like is required for a VSD then it shall generally be mounted as close to the VSD as possible and in compliance with manufacturer recommendations.

Where Unistrut or the like is used to mount VSD to the wall then the Unistrut shall be on continuous bars for all drives and not multiple short sections for individual drives. Variable Speed drives shall be mounted on at least two (2) horizontal rails or a suitable backplane.

9.4.4 Protection

The variable frequency inverter shall be provided with integral protection for:

- Overvoltage
- Under voltage
- Over temperature
- Short circuit
- Earth fault
- Inverter overload
- DC Bus Voltage Failure.

The integral motor protection shall provide a two body thermal model with user adjustable heating and cooling time constants, with indication and trip for the following:

- Thermal overload
- Timed Overcurrent
- Timed Under current
- Stall
- Earth fault
- Phase imbalance
- Motor thermistor temperature
- Bearing temperature.

The unit shall prevent a hot restart if the start would result in a trip before the end of the acceleration time.

The unit shall maintain an accessible history log of starts and start times. It shall provide adjustable pre-trip warnings for:

- Thermal overload
- Phase asymmetry
- Overcurrent
- Earth fault
- Undercurrent pick-up.

Comprehensive fault current protection for the power and control electronic systems shall be provided within the drive cubicle.

Any required semiconductor fuses shall be provided with signalling and alarm features to allow identification of the operated fuse element.

Inter-tripping to the circuit breaker shall be included where required.

Earth Leakage protection may be required for personnel safety as determined by AS/NZS 3000.

9.4.5 Harmonics, EMC and Power Factor

The VSD shall not impress generated voltage and current harmonics into the supply system greater than those allowed by the local supply authority. The latest Supply Authority Planning Manual shall be referred to for acceptable limits during design and a compliance with the minimum standards are required.

Where the VSD voltage harmonics exceed those specified either in applicable Standards or Supply Authority requirements, additional mitigation of harmonics shall be undertaken via external circuit modifications and/or the installation of additional equipment.

Detailed design shall cover of the requirements for cabling, earthing and filtering arrangements proposed in order to meet current applicable standards.

The installation and earthing of the converter components, enclosures, motor cabling, and the motor shall be done to ensure compliance.

Load side chokes/filters shall be provided and installed where cable lengths are deemed too long as recommended by the manufacturer.

The power factor of the VSD shall be greater than 0.95 for all normal running loads from 70 % speed to 100% speed.

9.4.6 Control and indication

The control module shall feature digital technology, programmable from a keypad, with a digital display showing the drive parameters in clear English, values in engineering units, password protection to minimise unauthorised changes to drive parameters, and internal backup of drive parameters. The keypad and digital display shall be accessible from the front operating face of the switchboard of VSD.

The VSD shall be provided with at least the following inputs:

- Analogue speed control, 4-20 mA
- Digital input for run
- Digital input for auto/manual
- Digital input, programmable for user defined functions.

The VSD shall be provided with at least the following outputs:

- Fault relay
- Analogue motor speed, 4-20 mA
- Auxiliary relay, programmable for user defined functions.

The VSD shall be supplied with appropriate communications card for integration with the site control system and for particular use in speed control and monitoring.

The following drive parameters shall be available at the digital display without the use of passwords:

- Output Frequency (Hz)
- Motor Current (A)
- Reference Frequency (Hz)
- Drive status (Run, Stop, Fault)
- Cause of a trip (e.g. Overcurrent, Overvoltage, and Over temperature, etc.)
- Pre-trip drive parameters recalled from the VSD fault memory log
- Variable Speed Drive Starters.

9.4.7 Functionality for energy efficient, well and pump cleaning VSDs

Section reserved for future use.

10. Motors

10.1. General requirements

Electric motors shall have an enclosure designation of at least IP 56 (for non-submerged applications) and IP68 (for submerged applications). Electric motors intended to be fully submersed shall have a protection of IP68.

Independent IP type certificates shall be made available upon request.

Motor output and dimensions shall be in accordance with AS60034 for motors within the range of that Standard.

Each motor shall be fitted with stainless steel nameplate complying with the relevant standards. The name plate shall also state the mass of the motor in kg.

The motors shaft shall be fitted with neatly fitting shaft keys. An anti-seize type grease coating shall be applied to the shaft before the coupling, pulley or any other power transmitting device is fitted to the shaft.

10.2. Three-Phase Motors

10.2.1 General

Each motor shall be manufactured in accordance with AS60034 series and shall be suitable for connection to a three phase, 415 V, 50 Hz, multiple earthed neutral supply.

All motors shall be 4-pole unless otherwise specified and agreed with Unitywater. Approval is required when deviating from 4 pole motors.

Unless otherwise approved, the maximum continuous rated shaft output of the motor shall be at least 10 % greater than the design duty-point or equal to the most severe operating-point power of the driven machine whichever is greater.

The motor shall comply with the requirements of the Standard Specification for Mechanical Installation (Pr9693) and especially with respect to noise and vibration.

Unless otherwise required motors shall be squirrel cage induction motors.

Standard motors shall conform to Design N as defined AS60034.12.

10.2.2 Design

Electric motors shall be of the totally enclosed fan cooled type, fitted with ball or roller bearings designed for a nominal life corresponding to 40,000 hours at full load operation when the motor is direct coupled to the driven machine.

Motors shall be capable of operating continuously at any frequency between 48Hz and 52Hz at a voltage which may vary within +/-10% of the nominal value.

Motors shall be suitable for up to at least fifteen (15) starts per hour or more frequent as applicable to the specific operational requirements of the motor, except where it can be demonstrated that such a frequency of operation is unwarranted or impractical for the motor in question and approval from Unitywater Electrical Engineering personnel is provided.

Motors to be subjected to high striction torques, high inertia loads or other special loads shall be entirely suitable for the duty, and the motor vendor shall guarantee the motors suitability for these conditions.

Unless otherwise specified motors shall be capable of two starts in quick succession with the motor at normal operating temperature.

Unless otherwise specified and approved by Unitywater, all motors shall be suitable for automatic restart at 80% of rated voltage.

The safe stall time from hot and cold must be specified by the supplier.

Motors for use on VSD shall comply with AS 60034.17 and be sized and guaranteed fit for the purpose including continuous operation at low speeds.

10.2.3 Enclosures

All electrical motors to be used outdoors in open areas shall be specially weatherproofed and suitable for use in a high humidity, with fungicidal treatment to the stator winding. All gaskets shall be one piece.

Motors that will be installed vertically with the fan at the upper end shall have a stainless steel rain shield fitted over the fan end of the motor The fan cowl shall be 316 stainless steel and all fixings shall be 316 stainless steel.

TEFC Motors located outside in a wet or dusty environment should be fitted with Dust shields.

The enclosures provided shall have sufficient internal bracing so as to withstand the wind forces expected on site.

Dosing pump enclosures shall completely prevent exposure to the weather without derating the drive due to heat.

10.2.4 Terminal box

Terminal boxes shall be centre-mounted and shall be capable of rotation through four times 90° to allow cable entry from different directions. Terminal boxes shall be oriented for bottom entry and shall use stainless steel fixings.

An earthing terminal shall be provided in the terminal box of 415 VAC motors. The earth terminal shall be sized to continuously carry motor full load current.

All terminal boxes shall be protected to IP56.

Main terminal boxes shall be designed for air termination of copper conductors. All motors 5.5 kW and above shall have six ends out to the terminal box.

Motors shall have separate IP56 terminal boxes for space heaters, thermistors, RTD's and other accessories.

Main terminals shall be marked in accordance with AS60034.8.

Cable terminations will be made by suitably sized lugs.

Captive screws shall be fitted on all terminal box lids.

10.2.5 Submersible motors

For submerged motors a 660 V motor cable suitable for use under water shall be supplied and connected to the motor by means of a watertight joint.

The cable shall be solid where it passes through a gland and be encapsulated in an appropriate sealant. The other end of the cable shall be terminated into the associated LCS. All submerged motors shall incorporate suitable integral seal failure functionality.

The submersible motor cables shall provide power and any control or monitoring required for the motor. The cable shall be to the required length to reach the terminators in the LCS.

10.2.6 Winding protection

Motors 11kW and above shall be installed with thermistor protection. Thermistors shall be of the PTC resistor type connected in series, one per phase, integral with the stator windings and clearly marked in the terminal box. The terminals shall be wired to a separate terminal box labelled 'THERMISTORS'. The location of winding thermistors shall be at the hottest point in the stator winding for that machine.

The thermistors, their fittings in the motor, reference temperature and testing of the motor shall be in accordance with AS/NZS IEC 60947. All instruments shall be suitable for continuous unattended operation and shall maintain their rated accuracy with a minimum of maintenance or need for adjustment and re-calibration.

Motors 110kW and above shall be installed with six RTDs (PT100) embedded prior to impregnation in the stator winding at equal intervals around the periphery. The winding RTDs shall be wired to a separate terminal box labelled 'Winding Temperature'. The RTD leads shall be terminated to RTD to 4-20 mA converters. The converters shall be of the two-wire self-powered type.

The bearing temperature RTD shall be terminated in suitable housings that will accommodate the RTD to 4-20 mA converters. The RTDs shall be terminated to the converters.

The manufacturer should provide recommended alarm and trip temperatures for RTDs.

10.2.7 Bearings

Bearings shall be in accordance with the manufacturer's standard for various sizes of motors. Rolling element bearings shall be used. Sleeve bearings may be offered if no suitable alternative exists.

Ball or roller bearings in all motors frame size 132 and larger shall be provided with grease nipples and relief valves to automatically eject old grease from the bearing housings. All systems (grease valve) should have ability to be purged whilst running. Greasing systems should also force new grease into the back of the bearing whilst exhausting old grease to atmosphere to ensure that the maximum amount of old grease is expelled.

Grease purging shall incorporate V-ring seal to prevent ingress of moisture into the bearing. The removal of an exhaust plate/plug when regreasing is NOT acceptable.

All bearings fitted with a grease relief system shall be fitted with studs for condition monitoring.

All rolling element bearings shall have metallic cages. Plastic cage bearings are not acceptable.

Ball or roller bearings shall have an L10 rated life of at least 50,000 hours for radial loaded applications and 100,000 hours for direct-coupled applications.

Bearing shall be of standard types, enabling replacements to be readily available from recognised bearing manufacturers. Bearings of SKF, NSK or FAG must be provided.

Dummy bearings should be fitted for the transport of sleeve bearing motors.

Shaft voltages shall be measured and included on the routine test on all motors 355 Frame and above. Insulated bearings shall be fitted to both ends of motors with shaft voltages exceeding 250 mV.

Shaft end float shall be stated for all motors 250 Frame size or larger to enable a check to be made on the end float of the coupling to be supplied with the driven equipment.

Where sleeve bearings are used, the Magnetic centre should be marked on the motor as well as the limits of end float.

Motors 200 Frame size and larger, or where supplied from a VSD shall be fitted with insulated non-drive end bearings.

10.2.8 Direction of rotation

Direction of rotation shall be as specified or as required by the manufacture of the driven equipment.

Three phase LV motors shall be bi-directional unless otherwise approved. Efficiencies and performance data supplied shall be for bi-directional rotation where applicable. Uni-directional motors shall have the direction of rotation clearly marked.

Any change in direction required after installation shall be undertaken directly at the motor terminal box or at the load side of the LCS for submersible pumps.

10.2.9 Painting

All motors shall be primed and painted with 2 pack epoxy paint suitable for the environment.

The manufacturer's standard epoxy painting system may be acceptable if it provides protection against a marine environment and is approved by Unitywater Engineering Personnel.

The preferred finish colour shall be Orange X15 to AS 2700.

10.2.10 Hazardous area motors

Motors installed in Hazardous Areas shall be manufactured in accordance with AS/NZS 60079. Certification shall be provided with the motors.

All Hazardous Area motors shall be supplied with thermistors.

Motors using the Ex e protection technique shall be have its tE time and IA/IN ratio clearly marked on the nameplate. Ex e motors supplied from VSDs shall be type tested and certified in accordance with AS/NZS 60079.

10.3. VSD driven motors

Motors supplied for use with VSDs shall be suitable for the application.

Where motors are required to run continuously at low speeds, consideration should be given to additional forced cooling by way of cowl mounted auxiliary fan. This requirement should be confirmed with the motor vendor.

Where required, the VSD and motor shall have the necessary output filters or other protection devices to prevent any degradation or premature failure of the motor.

10.4. Single phase motors

Section reserved for future use.

11. Field equipment

11.1. General

Unless specified elsewhere, all electrical field equipment shall be housed in an enclosure constructed entirely of 3 mm marine grade aluminium or 1.6 mm 316 stainless steel with a minimum protection rating of IP56 for all areas.

Enclosures shall be mounted to give easy access for maintenance purposes. The enclosure shall not obstruct walkways or restrict access for maintenance purposes to other items of plant. No enclosure shall be mounted on items which may need replacing or repairing due to normal wear.

Cable termination facilities shall be arranged to permit cable entry into the bottom of the enclosure only.

Provision shall be made for sealing enclosures after the installation of field cabling. All cable entries should be via IP rated glands to ensure IP rating is maintained.

Spare cable entries shall be sealed with screwed plugs with applicable rating for the device.

All fixings shall be 316 stainless steel. Self tapped fixings shall not be used.

All fasteners shall be captive to the enclosure body or lid.

Plastic components, e.g. pushbuttons, lights and switches, shall not be exposed to direct sunlight unless suitably rated. Any enclosures housing equipment with LCD displays shall be positioned in a north/south aspect to avoid direct sunlight.

Field equipment/control panels must not be installed within bunded areas or hazardous area e.g. chemical dosing. Where the equipment is to be located near these areas, unimpeded access for emergency egress purposes must be provided

All underground flow meters shall be installed within a suitably sized pit. Pits shall also be provided with adequate drainage to the plant or a sump pump.

Local control shall be limited to proprietary equipment with local control minimised and all control fully configured in the plant control system.

11.2. Mounting of instruments and enclosure

Mounting methods shall at all times be suitable for the mass and duty of the device and the environment into which it is to be mounted.

Sunshades shall be provided for all field instruments to protect against mechanical damage, solar heating and UV damage where exposed to these conditions in the installed position. Sunshades shall have a forward sloping roof.

Where instruments use transmitters that are separate from the sensor, and the transmitters are not housed in enclosures, the transmitter shall be mounted on a stainless steel bracket with a sunshade for protection against mechanical damage, solar heating and UV damage.

Indicators and transmitters with integral displays shall be mounted to avoid exposure of the LCDs and membrane keypads to direct sunlight. The preferred orientation of the displays and indicators is facing south or east.

Displays and indicators shall be mounted at a height of between 500 mm and 1600 mm above the surrounding ground level.

Instruments and enclosures shall be mounted in such a way to maintain the IP rating of the instrument/enclosure.

11.3. Local Control Stations

The term Local Control Station (LCS) shall be taken to include all associated works including mounts/foundations, base, stands, sunhoods, equipment and enclosures.

LCS shall be designed to meet operational requirements.

In general LCS will be installed for the operation of a certain piece of equipment or process.

LCS shall have isolators, push buttons and selector switches as required for each individual drive.

LCS shall be constructed entirely of 3 mm marine grade aluminium or 1.6 mm grade 316 stainless steel with sunhood and supported on a marine grade aluminium channel post and base with cover plates.

The LCS equipment enclosure shall preferably be proprietary units, and shall have the following mounted behind a locked door on an escutcheon:

- Start pushbutton
- Stop pushbutton
- Local/Off/Remote selector switch
- Load breaking local Isolator
- Forward/off/reverse (if applicable).

A local latching stop button shall be accessible without the need for a key.

The LCS shall be sufficiently deep for at least two contact blocks to be used per operator.

A terminal strip for all control wiring and a safety strap, to support open front cover if not supported by hinges, shall also be provided.

LCS shall not be used for the looping or marshalling of cables.

The load breaking local isolating switch shall have an AC23 rating for the motor being isolated and shall be lockable in the off position and be fitted with an auxiliary interlock which shall be wired into the motor control circuit.

The internal control wiring shall be terminated on rail-mounted terminals and be ferruled appropriately.

Live parts shall be shrouded to IP20 to protect against accidental contact when the escutcheon cover of the LCS has been opened.

Gland plates shall be removable and minimum 3mm Marine grade aluminium with 3mm gasket.

11.4. Junction boxes

Junction boxes shall be used for the marshalling and looping of all field cabling and housing of field surge protection devices.

Junction boxes shall be constructed from a minimum of 3 mm marine grade aluminium, 1.6 mm Grade 316 stainless steel with a minimum protection rating of IP56. Polycarbonate, UV resistant enclosures may be considered for small junction boxes only where vendor cables are provided to final field equipment.

All fasteners shall be stainless steel and captive to the lid.

Junction boxes shall be mounted to give easy access for maintenance purposes.

Junction boxes shall be mounted in such a way to maintain the IP rating of the junction box. Self tapping screws are not acceptable.

The junction box shall not restrict access for maintenance purposes to other items of equipment.

No junction box shall be mounted on items which may need replacing or repairing due to normal wear.

Junction boxes shall be of ample size to enable the cables to be neatly diverted from one conduit to another without undue cramping.

Junctions shall be effected through terminal strips within the junction box.

Separate junction boxes shall be provided for each different drive or equipment system and for sections of different systems which are not able to be isolated at one location.

Junction boxes shall be located in accessible locations and either fixed to the building structure or stanchion at a height of between 1100 mm and 1300 mm.

Where junction boxes have a door then all doors shall be fitted with 316 stainless pentile hinges, a minimum of three to be fitted if over 1200 mm in height and be secured with 316 stainless steel 8mm solid square latches

11.5. Local Control Panels

Reserved for future use

12. Light and Power

12.1. Lights - general

Lighting shall be supplied and installed in locations to ensure that adequate lighting levels are maintained for operational and maintenance tasks to be performed. Lighting calculations for all areas shall be provided so the required quantities, ratings and optimum layouts of luminaries may be established. All luminaries shall be high energy efficiency types. Light fittings shall be manufactured in accordance with the requirements of AS 60598.1.

All external light fittings shall be rated to a minimum of IP65 degree of protection.

Where fittings are subject to vibration suitable anti-vibration mounts shall be supplied and installed.

Where power factor correction capacitors are used, they shall be of a value to correct to power factor >0.9.

Internal wiring shall be run neatly, without stress, securely fixed and so placed that contact with parts that generate heat is avoided.

A terminal connector block shall be fixed adjacent to the cable entry hole for the connection and looping of fixed wiring.

Nuts and screws shall be fitted with Starlock or similar approved type washers. All fastening devices shall be positively held so they may be undone and remade without access to the back of the fitting. Internal wiring shall be PVC V105 24/.5 flexible conductors with crimped termination lamp holder and starter sockets contacts.

All fittings shall be supplied complete with all necessary mounting brackets, accessories and lamps.

Luminance levels are shown in Section 12.7.

All lighting circuits shall have a socket outlet that can be used as a test point except where automatic RCD testing is incorporated as per Section 12.8. These socket outlets must be accessible without being near exposed live parts.

12.2. Switchboard lighting

Light fittings shall be mounted inside the switchboard at appropriate and strategic locations.

The number of light fittings and their positioning within the switchboard shall be determined throughout the design process.

Lighting provided will direct light onto the surface of the escutcheon/backplane while not directly causing glare that may impede the technician’s work.

Switchboard lights shall be controlled by appropriately and strategically placed door switches that automatically turn the lights on when the cubicle door is opened.

12.3. Area lighting – external plant areas

General plant area lighting shall be provided via lighting columns.

Suitable external lighting shall be provided around the plant access routes, with additional local lighting to specific areas.

These lights are to have SCADA control and in specific instances a local switch point. Lights within buildings shall always have a local switch point.

Lights shall be mounted and supplied with brackets that ease maintenance requirements, in particular, tilt poles shall be provided where reasonably practicable.

All exterior lighting shall have a minimum rating of IP65 and be corrosion resistant.

12.4. Building lighting

All fittings shall be located in positions that are easily accessible by means normally available to maintenance team members. Confirmation of lighting positions is to be defined during design.

Luminaires in clean, dry indoor locations shall be of the enclosed type, as a minimum a diffuser is required. All fittings in other locations shall be IP65 and corrosion resistant.

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.

Lighting shall be controlled by splash-proof switches located at each entrance to the area being controlled, with multi-way switching where more than one entrance is provided.

Where switches are installed next to hinged doors, the light switch shall be located on the non-hinged side of the door.

Emergency lighting shall meet the requirements of AS 2293.

Emergency exit lights (luminaries) shall provide evacuation or escape lighting to a level of not less than 0.2 lx along the escape route for a period of three hours.

Emergency exit lights shall be LED type.

12.5. Emergency Lighting – Safety Showers and Eyewash

Emergency showers, eye/face wash stations provide a critical safety function. Although the colour of lighting isn't specified in Australian standard AS4775-2007, the standard mandates highly visible signage and well-illuminated areas for each shower, or eye/face wash location throughout the served area.

Green lighting is required for all emergency shower/eyewash installations.

Emergency showers, eye/face wash stations lights are to be always on. Where there is potential nuisance light pollution impacting neighbouring residences, the designer and installation must consider options to minimise the impact to neighbours. This may include shrouding, covers, reflectors and directing lights.

12.6. Lighting control

The lighting control shall allow the lights to be activated at dusk for an adjustable period and re-activated for an adjustable period before dawn to allow personnel access and egress around the site. Further control will be outlined in the site lighting control philosophy.

Security lighting shall be switched by an external photocell working in conjunction with and controlled by the Plant control system. A lighting control philosophy for each plant shall be developed as part of each project and will be dependent upon the site. Exterior area/walkway lighting shall be controlled via the plant PLC and relay/contactor control.

Each area lighting circuit shall be capable of manual operation via the plant Control System with manual over-ride via a selector switch at the lighting distribution board.

Relays, contactors and other control gear associated with lighting circuits shall be housed within the respective light and power distribution board or MCC.

12.7. Luminance levels

Maintained luminance values shall be based on cleaning intervals of 24 months for luminaries and building surfaces.

The average luminance levels are outlined in **Table 14: Luminance Levels** below.

Table 14: Luminance Levels

Equipment Area	Average Luminance Requirement (lx)
Switchroom	240
Control Room	400 (at bench height)
Laboratory	400 (at bench height)
Internal Access ways	160
Fixed electrical and mechanical Plant	80
External Access/Egress Plant Area Lighting	40
External Security/Street lighting	10

Control room lighting shall comply with requirements for screen based equipment.

The spacings of the light fittings shall be in accordance with AS 2293.1 and AS 2293.3.

Testing shall be carried out to ensure the stated illumination levels are reached.

12.8. Power

12.7.1 General Purpose Outlets

General purpose outlets installed outdoors shall be 15 A switched outlets, RCD protected, hose-proof and weatherproof to IP56 degree of protection, high impact polycarbonate.

The outlets shall be installed in convenient locations as developed during the design and shall be mounted on nearby structures or buildings where possible.

General purpose outlets installed indoors shall be 10 A double switched outlets, RCD protected unless otherwise required by this specification or the project requirements.

General purpose outlets supplied by UPS shall be coloured red.

General purpose outlets installed within buildings shall be installed in convenient locations and shall be detailed during design.

12.9. RCD Testing

Where a distribution board or switchboard contains more than 10 RCD then a safe method of testing RCD must be provided such that panels need not be opened to perform tests.

The preferred method is through a permanently installed automated testing device as described in F10678 - Accepted Electrical Equipment List.

Test points are acceptable for lighting circuits where there are less than 10 RCD in total (for power and/or lighting) for the installation.

13. Uninterruptible Power Supply (UPS)

13.1. General

At least one Uninterruptible Power Supply (UPS) system shall be provided. The location will be dependent upon site requirements but usually will be installed in the main switchroom.

The UPS shall generally provide power for:

- Operator display client
- Engineering Workstation
- PLC equipment
- Server and/or Communication racks (a non-UPS backed supply is also required see Section 7.6)
- Instrumentation
- Laboratory equipment.

The UPS shall have a minimum of two hours back up time at the standing load.

UPS power shall be distributed via a separate distribution board.

The distribution board buses shall be protected with a bi-directional surge diversion device rated at 10kA (8/20µs) via a suitably rated protective device.

This surge unit is to give protection to load circuits should the UPS supply not be available and also protect against surges entering via the field load circuits.

13.2. UPS System

13.2.1 General

The UPS shall comprise the following components:

- Rectifier/Battery charger
- Inverter
- Control and Indication
- Static bypass
- Internal maintenance bypass
- Bypass line conditioner (where required)
- Sealed Battery set
- Battery stand/enclosure
- Battery circuit breaker
- External bypass switch (Maintenance bypass switch)
- Test load circuit breaker (where required)
- Test load (where required)
- Battery maintenance tools.

The UPS shall be capable of the following modes of operations:

- Normal mode
- Emergency Mode
- Bypass Mode
- Down-graded Mode.

13.2.2 Parallel operation

The UPS shall be capable of parallel operation with an identical unit in synchronised load sharing mode. Where one UPS fails, the entire operating load shall be automatically shifted to the other UPS without interruption. Full functionality and 100 % rating as per the project requirements shall be provided by each UPS in the parallel system such that one UPS can be removed from service with no downgrade in system functionality or backup time.

In normal operation, the output of each inverter shall synchronize to the bypass AC line. The failure of one UPS shall automatically cause the remaining inverter to assume the full load without power interruption. In the event of a failure or unavailability of the second inverter, the load shall be automatically and instantaneously transferred to the bypass AC line without power interruption to the load.

Circuit breakers or load disconnect switches shall be provided at the output of each UPS module for the purpose of isolating one or both UPS units from the load bus. Both UPS shall supply a common output bus.

Each UPS in a parallel load sharing system shall be installed in its own separate enclosure. If one unit is taken out of service for any reason, it shall be possible to manually place it back in service and reconnect it to the load bus without any disturbance to the other UPS or the load.

The Maintenance bypass switch shall be common to both UPS sets.

13.2.3 System rating

On loss of mains power each UPS shall be capable of continuously maintaining the rated standing load for a minimum of two hours whilst maintaining the voltage level within the specified limits with the batteries initially fully charged. The stated rating is inclusive of load factors.

The overall UPS efficiency shall be greater than 95% with the batteries charging at the maximum rate and the UPS supplying full load.

13.2.4 Supply system

Under normal conditions the rectifier shall supply the power requirements of the inverter (fully loaded) and float charge the battery. On restoration of the normal supply, charging of the battery shall be initiated, and the rectifier shall supply the inverter (fully loaded) and, simultaneously, charge the battery. If supply to the load from the inverter fails, the static bypass switch shall transfer the load to the bypass supply. Transfer back to the inverter output shall be selectable as either automatic or manual. Provision shall be made for manually transferring the load to the internal static bypass or external maintenance bypass supply.

13.2.5 Environment

The UPS shall be housed in an air conditioned switchroom or other air conditioned building. The associated batteries will be housed in the same location. The equipment shall be designed to operate at the maximum ambient temperature shown in the site service conditions in Section 3.1.2.

The UPS and enclosure shall have a minimum rating of IP41.

13.2.6 Noise

The maximum noise level produced by the UPS shall be 50dB. This figure shall apply under all load conditions, with all panel doors closed and ventilation fans running.

Noise shall be measured 1 meter from the panel face.

13.2.7 Interference protection

The supplied equipment shall conform to all relevant IEC Standards with regard to Radio Frequency Interference emissions and harmonic distortion.

13.3. Components of UPS

13.3.1 Rectifier/battery charger

The rectifier input shall be single phase.

The rectifier shall be of the constant voltage, current limited type and shall be correctly sized and rated for the requirements of both the batteries and the load.

The supply input to the UPS battery charger shall be fitted with a manual isolation switch and overload protection. Semi-conductor protection fuses if required shall be included as part of the UPS.

The output voltage and battery charging current shall be selected to suit Section 13.3.7.

The current rating shall be sufficient to supply the full rated load, whilst simultaneously charging the batteries.

The rectifier shall have the following protection features as minimum:

- Internal current limiting to protect the output against overcurrent
- Automatic shut down if the DC voltage exceeds the maximum value allowed by the batteries or on over temperature
- Automatic shut down on over temperature.

13.3.2 Inverter

The inverter shall be a solid state, self-commutating type with single phase output.

The inverter shall be capable of operating within its output tolerances when supplying loads over the range between zero and full load and at the range of load power factors, with inverter DC input voltages varying over the range of battery voltages from discharged to fully charged.

The frequency shall normally be synchronised to that of the Bypass Supply but, if this supply goes out of tolerance, the inverter shall use its own internal, crystal oscillator generated frequency.

The output shall be fitted with overload protection to prevent damage to the inverter in the event of an overload/short circuit on the inverter output. The inverter shall be capable of supplying an overload of 150% for 1 minute and 125% for 10 minutes before operation of the static transfer switch.

The inverter shall have sufficient short circuit driving capacity to trip the load circuit breakers without operating either the current limiting feature or the static transfer switch.

The harmonics on the output shall be suitable for the connected loads and shall not exceed 3% Total Harmonic Distortion with 100% non-liner loads.

The UPS output bus shall be filtered and protected against surges, sags, and harmonic variation by the deployment of surge suppressors and appropriate voltage correction devices as mandated by IEEE 519 and IEEE C 462.41.2.

13.3.3 Controls and protection

The following minimum controls and indications shall be shown on SCADA and be accessible on a local display (may be part of UPS unit).

- Switches:
  - Inverter on/off
  - Static Transfer Switch controls
  - Internal Maintenance Bypass.
- Indicators:
  - Battery Charge - on/failed
  - Battery volts - high/low
  - Inverter - failed/synchronised
  - Load on - inverter/bypass
  - Batteries supplying load (Battery Discharge)
  - High/low inverter DC input voltage
  - Static switch on bypass AC line
  - Battery disconnected
  - Enclosure over-temperature
  - Mains volts
  - Battery charger volts
  - Battery current
  - Output volts
  - Output current.

13.3.4 Static bypass switch

The static bypass switch shall provide for transfer of the load from the Inverter output to the bypass supply or vice versa.

In either automatic or manual mode, transfer shall occur in synchronism and without interruption.

Transfer from inverter output to bypass supply shall be initiated automatically by inverter fault, excessive overload or manually by pushbutton.

For transfer from the bypass supply back to the inverter output, the system shall be provided with a selectable option of an automatic return after a pre-set delay or a manual return initiated by pushbutton.

13.3.5 Internal maintenance bypass

A manually operated maintenance bypass shall allow the UPS internal equipment to be taken off line for maintenance. When the maintenance bypass is operating, all UPS equipment shall be isolated with the exception of the bypass equipment, which shall be suitably screened and marked.

13.3.6 Bypass line conditioner

The bypass line conditioner shall filter against supply spikes and glitches appropriate for the needs of the loads (instruments, DCS, computers etc.).

The bypass line conditioner shall consist of one of the following options:

- an isolating transformer
- an isolating transformer complete with electronic conditioning
- a UPS of the same design as the main units but without batteries fitted.

The required type will be as shown in the data sheets.

13.3.7 Batteries

The battery set shall be capable of starting the UPS even if no AC power is available (cold start) while still maintaining the required backup time.

13.3.7.1 Battery selection

Batteries shall be sealed, leak-proof and maintenance free. Batteries and battery chargers shall be mutually compatible.

The batteries shall have a guaranteed lifetime that complies with Section 3.1.2 in the given application.

The batteries may be mounted either in the UPS cabinet or a separate battery cabinet (only if rack is not big enough to hold all relevant equipment) or on open racks. The mounting enclosure shall be impervious to the effects of the battery electrolyte used. A minimum clearance of 150 mm shall be maintained above each cell to allow proper air circulation. A minimum clearance above the cells (when the enclosure lid is open) shall be 300 mm. Adequate clearance shall also be maintained in between cells. The minimum air space between cells and between cells and external walls of the enclosure shall be 10 mm. Cells shall always be positioned in such a way that the electrolyte level markings (both minimum and maximum) can be easily seen.

Batteries shall have circuit breaker short circuit protection which may be also be used to isolate the batteries from the charger/inverter. When the batteries are isolated, the UPS shall continue to supply the load with interruption (providing there is no mains power shortage)

Battery maintenance tools shall be housed in a suitable space within the battery cubicle or in a separate wall mounting cabinet.

13.3.7.2 Battery sizing

Batteries sizing shall be based on supplying the specified load for the required backup time at the specified ambient temperature whilst maintaining the specified minimum output voltage.

The following sizing factors shall be applied in sizing the batteries:

- Design margin 15%
- Aging factor 125%

13.3.7.3 Battery monitoring

The UPS shall be capable of monitoring its respective battery set to determine if the battery is failing. This monitoring shall be automatic and ongoing and shall not require additional equipment to be fitted to the batteries.

13.3.7.4 Battery installation

Where the voltage of the battery exceeds 120 V, the batteries shall be provided with isolating switches, plugs or links to separate the battery into sections of less than 120 V for maintenance. Suitably identified inter-cell connectors with insulation of a different colour to other connectors may be used for this purpose.

13.3.8 External bypass (maintenance bypass switch)

An external bypass shall transfer the load from the UPS/bypass output to an alternative power supply. The external bypass shall consist of a manual make-before-break transfer switch with an electrical interlock connected to the UPS to prevent transfer of the output when the UPS output is not synchronised to the supply. The switch shall be fully rated for the UPS load and installed in a separate wall mounted enclosure.

When the switch is in the alternative supply position, it shall be possible to completely disconnect the UPS and batteries from all power supplies and remove it for maintenance.

The bypass switch shall be provided in its own wall mounted enclosure.

An auxiliary contact indicating that the switch has been set to the Bypass position shall be wired to the Plant Control System.

13.3.9 Internal devices

Isolating devices shall comply with the requirements of AS/NZS IEC 60947.1 as appropriate for the duty of the device. They shall be pad lockable in the off position.

13.3.10 Maintenance

Equipment design shall allow testing and calibration of control and logic circuits while the UPS loads are switched to the bypass AC line. Test points and diagnostic lights shall be provided to facilitate adjustments and repairs.

13.3.11 Panel construction

13.3.11.1 General

The UPS rack shall be a standard full height (43RU) rack and standard width.

13.3.11.2 Construction

The UPS shall comprise free standing metal clad panels suitable for indoor operation.

The total enclosure shall have a minimum ingress protection rating IP41.

Cubicle steel plate shall generally not be less than 1.6 mm. Cubicle doors shall be stiffened where necessary to prevent warping.

Each compartment shall be lockable and capable of being completely isolated from all supplies incoming and outgoing, prior to opening.

All live parts within the panel shall be fully shrouded to prevent accidental contact of live parts during commissioning and maintenance.

All controls shall be mounted on the door with labels correlating to that of the mimic diagram. It shall be possible to perform all switching operations with the panel door in the closed and locked position.

Generally forced ventilation will not be accepted, however if forced ventilation is required to dissipate heat from the panel the room air conditioning system shall allow for the total heat losses to the room housing the UPS system and be sized accordingly.

13.3.11.3 Gland plates

Gland plates, if required, shall be provided at the bottom of the panel only and sized to suit the required number and size of cables.

13.3.11.4 Panel wiring

All panel wiring shall be in accordance with Switchboard wiring requirements outlined in Section 4.5.

13.3.11.5 Terminal strips

All control wiring leaving the UPS shall terminate on fully identified terminals, or terminal strips of adequate size and current rating. Terminal strips shall be identified in accordance with the appropriate schematic and/or terminating diagrams.

Extra terminals with bridging links shall be provided where multi-terminations are required.

All spare ancillary controls shall be wired down to spare terminals on terminal strip.

13.3.11.6 Earthing

An earth bar shall be provided at the bottom of each panel for common connection to all non-current carrying parts.

The earth bar shall be meet the requirement of AS/NZS 3000 and shall be suitable for terminating cables up to 70 mm^2 earth cables for external bonding.

All doors and hinged metallic parts shall be connected to the earth bar by minimum 6 mm^2 earth cable conductors.

The positive and negative buses of batteries shall be isolated from earth ground.

13.3.11.7 Lifting lugs

Where necessary removable lifting lugs will be provided for transportation and erection purposes.

13.3.11.8 Painting and protective coatings

Standard paint finish as per Switchboard requirements in Section 4.9 shall be applied.

All finishes and materials used on battery enclosures or supports shall be resistant to the effects of the electrolyte used.

13.4. UPS normal mode

During normal operation the UPS shall provide precisely regulated and transient free power to its load.

Power to the rectifier shall be supplied from the primary AC source.

The rectifier shall supply the inverter with regulated DC power.

The inverter shall convert the DC power into regulated AC power for the load.

13.5. UPS emergency mode

On failure of the primary AC power, input power to the inverter shall be supplied from a battery bank.

When the AC power is restored, input power to the inverter shall be supplied automatically from the rectifier.

If the AC power is not restored before the discharge limit of the battery is reached (the discharge limit being designated by the battery manufacturer, the UPS shall automatically shut itself down in an orderly manner.

A signal shall be given to the plant control system when the AC power fails and power is supplied from the battery bank.

A signal shall be given to the plant control system of impending shutdown 15 and 5 minutes before time-out.

13.6. UPS bypass mode

The static switch shall transfer the load automatically without interruption to an alternative source of AC power on a failure of the UPS output.

A similar manually initiated facility shall be provided so that the UPS can be taken-out of service for maintenance.

Circuit breakers shall be provided as part of the static switch such that the complete UPS including the static switch may be isolated electrically for maintenance once the load has been transferred to the alternative source.

Retransfer for the load shall be accomplished automatically by the synchronising the UPS to the alternate source, paralleling the UPS to ramp into the load finally disconnecting the alternate source.

13.7. UPS down-graded mode

When it is necessary for the batteries to be taken out for maintenance, the DC input to the UPS shall be disconnected manually by a circuit breaker.

Under these conditions the UPS shall continue to operate as specified herein save for the loss of operation from the battery.

13.8. Remote monitoring and alarms

The system shall be provided with alarms that can be monitored by the Plant control system as well as locally displayed within the UPS unit itself.

The system features shall include:

- Individual annunciation for each alarm
- 'Latch-up' for each alarm on fleeting alarms
- Manual alarm reset; operation of this button shall reset any latched up alarm if the initiating condition has returned to normal.

Alarms shall be combined into the following groups with matching voltage free contacts provided for remote indication of the alarms to the plant control system:

- Group Alarm, WARNING; abnormal or warning conditions such as low battery volts
- Group Alarm, TRIP: fault or shutdown/tripped conditions.

An alarm to indicate the battery circuit breaker open condition (or fused disconnect switch open or blown fuse condition) shall be provided as a voltage free contact wired to terminals for connection to plant control system.

All alarm relays shall be fail safe operation, i.e. de-energised in the alarm condition. They shall be fitted with a minimum of one normally open and one normally closed voltage free contact connected to terminals so as to provide a remote alarm repeat facility.

The rating of alarm contacts shall be 2A at 24V DC.

13.9. Ethernet communication

Monitoring of the UPS and battery charger system shall be via Ethernet/TCP communication link to the plant control system.

14. Power Factor Correction

14.1. General

The PFC units are required to operate continuously and maintain a minimum power factor of 0.95 lagging for the switchboard they are connected to.

Power factor correction units shall be suitable for permanent connection to the main switchboard.

The Power factor correction equipment shall provide multiple stage switching, four (4) switched stage minimum. Steps shall not exceed 25 kVAr.

Discharge devices shall reduce the terminal voltage to 50 V within one minute of de energisation.

Power factor correction equipment shall be installed within air-conditioned buildings or switchrooms.

14.2. Capacitors

Capacitors shall be constructed of sealed stainless steel tanks fitted with overpressure and over-temperature switches that shall be input to the plant control system.

Aluminium or aluminium alloys shall not be used for any external fittings or components.

Inrush and harmonic blocking reactors shall be dry type.

Capacitor units shall be designed and installed with pressure switches to provide early isolation in the event of excess pressure within the relevant tanks.

14.3. Enclosures

Enclosures used to house power factor equipment shall comply with the requirements of Switchboard Construction outlined in Section 4.

Generally the building air conditioning system shall be utilised for maintaining constant temperature. The power factor correction equipment shall incorporate ventilation by natural convection or forced air cooling while maintaining the IP rating.

Detailed dimensions, weights and footprint for each power factor correction enclosure shall be provided at the design stage.

Suitable means (e.g. eyebolts) shall be provided for lifting and transport of the power factor correction unit either by crane or by forklift.

The capacitor shall be cleaned, primed, and painted in accordance with Supplier's standard practice that is applicable to the site service conditions (Section 3.2). Top coat finish shall comply with requirements for site service conditions.

14.4. Labelling

Labelling of the enclosure shall comply with relevant Australian Standards for statutory labelling and switchboard labelling requirements for general labelling (refer Section 16) for further information.

A main nameplate shall be provided and as a minimum shall show the equipment identification number and title, the Supplier's name and Unitywater project number and all relevant information relating to bus ratings, fault levels etc. This nameplate shall be engraved stainless steel. This nameplate shall be mounted next to the rating and connection plate.

14.5. Earthing

All earthing shall be installed in accordance with this specification, AS/NZS 3000 and related and referenced standards.

Each power factor correction unit shall be fitted with a copper earth bar of not less than 120 mm^2 section, to which shall be effectively connected all metal parts not intended to be live.

M10 earthing connection studs are required.

14.6. PFC controller

14.6.1 Control system requirements

Each power factor correction unit shall be provided with a complete control, instrumentation and protection system necessary for the safe and reliable operation of the unit. They shall be provided with interposing relays to interface with control devices where required. The controller shall interface with external control equipment via a communications link for the monitoring of the power factor correction unit operation parameters, alarm and trip conditions. The communications link shall be Ethernet/TCP or Profinet communication link to SCADA dependent upon PLC platform and shall comply with the requirements of Pr9833 SCADA and PLC Architecture.

14.6.2 PFC control panel

The PFC control panel shall be mounted on the enclosure. All controls shall be accessible from outside the enclosure. All functions of the PFC controller shall be available for use and wired into the plant control system.

Terminal strips shall be provided for all wiring between input and output modules and all devices internal and external to the control panel.

The following parameters shall be provided on each PFC unit control panel as a minimum:

- Voltage (phase and line)
- Current
- Frequency
- Power Factor
- Displacement Power Factor (cos ϕ)
- Real, Reactive and Apparent Power (P, Q and S).

Monitoring of the PFC system shall be via Ethernet/TCP communication link to the plant control system. All monitoring and configuration parameters shall be accessible via the Engineering Workstation.

14.6.3 Alarm and trip conditions

All alarm and trip conditions shall be monitored by the PFC control system and shall be annunciated at the PFC controller and on SCADA. The alarm conditions shall include but not limited to the following:

- Controller failure
- Low control voltage
- Enclosure over-temperature
- Capacitor fault
- Over-Current
- Over-Voltage.

15. Active Harmonic Filters

15.1. General

The active harmonic filters are required to operate continuously and maintain the Total Harmonic Distortion (THD) to below the limits defined in AS/NZS 61000.3.6. AHFs shall be suitable for permanent connection to the main switchboard.

The active harmonic filter equipment shall provide inverter switched capacitor banks to minimise harmonics created in the system.

Discharge devices shall reduce the terminal voltage to 50 V within one minute of de-energisation.

15.2. Type and arrangement

The active harmonic filter shall be of the shunt configuration and of 3-phase, 3-wire type to filter harmonics in the phases. It shall be connected at the LV level in an installation allowing for the reduction of harmonic stress at load level and to reduce transformer losses and harmonic emissions to the feeding network. The AHF shall be able to work on Supply Authority fed networks as well as on standby generators.

The active harmonic filter shall have the following features:

- Mitigation of harmonics from the 2^{nd} harmonic up to the 50^{th} harmonic and limit harmonic distortion at their point of connection to the limits defined in AS/NZS61000.3.6.
- Reactive power compensation. Target power factor must be settable up to unity. Both capacitive and inductive modes must be possible.
- Provide load balancing.

The active filter shall measure the network currents at the supply side of the unit allowing for closed loop control. Current Transformers (CTs) shall be class 1 accuracy minimum and be sufficient for proper filter operation.

The AHF power inverter shall be based on IGBT technology. It shall employ a Phase Width Modulation technology using a fixed switching frequency.

The communication between the main controller board and the individual power modules must occur through an optical link to provide galvanic isolation.

15.3. Enclosures

Enclosures used to house active harmonic filter equipment shall comply with the requirements of Switchboard Construction within Section 4.

Generally the building air conditioning system shall be utilised for maintaining constant temperature. The active harmonic filter equipment shall incorporate ventilation by natural convection or forced air cooling while maintaining the IP rating.

Detailed dimensions, weights and footprint for each power factor correction enclosure shall be provided at the design stage.

Suitable means (e.g. eyebolts) shall be provided for lifting and transport of the power factor correction unit either by crane or by forklift.

15.4. Mode of operation

The active harmonic filter shall monitor all three phases of the LV line current in real-time and process the measured harmonics by means of a Digital Signal Processor based system.

The output of the Digital Signal Processor based system shall be a Pulse Width Modulated signal to control power modules based on IGBT technology that shall be controlled as a current source.

The control of the power modules and associated reactors shall be such that harmonic currents of exactly the opposite phase of those to be filtered are injected into the source of supply to the filter so that the harmonic currents flowing in the line are reduced to levels that can be individually programmed by the user.

The system shall be operated under closed loop control. The control system shall be such that the active filter cannot be overloaded.

The active filter shall be able to co-exist with tuned and detuned capacitor banks in some way.

15.5. Filtering characteristics

The active harmonic filter shall be able to filter simultaneously at least 20 individual harmonic components, individually programmable in a frequency range from the 2nd to the 50th harmonic.

The degree of filtering shall be programmable for each harmonic in Amps.

The active harmonic filter shall allow for different filter modes to be set expressing the priority to be given to the filtering of harmonics and the generation of reactive power and load balancing.

The filtering efficiency shall not be less than 95%.

15.6. Reactive power compensation

The active harmonic filter shall be able to perform reactive power compensation and aim to compensate for a target displacement power factor ensuring correct operation in the presence of harmonics. The user must be able to choose this target power factor in a range from 0.6 lagging/leading to unity.

In addition, the filter shall also be able to generate or absorb a fixed amount of reactive power within the filter's current capabilities on the user's request.

15.7. Heat losses/power dissipation

The active harmonic filter shall have intelligent control technology that minimises the filter switching losses for each operating point.

The heat loss from each active harmonic filter operating at full load shall not be more than 5 % of the module rating per module.

15.8. AHF protection

The active harmonic filter shall incorporate its own protection devices that ensure protection against overcurrent, short-circuit, thermal overload, IGBT bridge abnormal operation, network voltage phase loss, network synchronisation loss and DC capacitor over and under-voltage.

15.9. Capacitors

Capacitors shall be constructed of sealed stainless steel tanks fitted with overpressure and over-temperature switches. Aluminium or aluminium alloys shall not be used for any external fittings or components.

Inrush and harmonic blocking reactors shall be dry type.

Capacitor units shall be designed and installed with pressure switches to provide early isolation in the event of excess pressure within the relevant tanks.

15.10. Monitoring

Monitoring of the PFC system shall be via Ethernet/TCP communication link to the plant control system.

All monitoring and configuration parameters shall be accessible via the Engineering Workstation.

16. Labelling

16.1. General

The switchboard and all modules shall be labelled with equipment number and title in accordance with the Single Line Diagram.

Every electrical device including but not limited to VSD, motors, instruments, circuit breakers, terminals, terminal strips, fuses, switches, test blocks, indication lamps, relays, local control stations, field and any other equipment shall be identified by a permanently fixed label.

Every label shall be fixed near the device and oriented so that it is readable. Labels must not be affixed directly to the device/equipment for replaceable items or to cable duct covers.

Labels shall give both the device title or function and a unique alphanumeric identification code.

Within a single drive module, all equipment shall be labelled as per the circuit diagrams.

All labels shall be fixed using stainless steel threaded screws.

All nameplate and device labels within switchboards and any other enclosure are to be engraved with white/black/white traffolyte laminated engraving. Proprietary legends may be exempted from this requirement.

The Main Switch/Main Isolator label for switchboards shall be engraved with red/white/red traffolyte laminated engraving material.

All labels wider than 30mm shall be fixed using stainless steel threaded screws.

All device labels within switchboards and any other enclosure are to be engraved with white/black/white traffolyte laminated engraving material and are to be fixed using stainless steel threaded screws. Proprietary legends may be exempted from this requirement,

External labelling shall be etched 316 stainless steel and fixed by 3mm stainless steel threaded screws or by means of a dog tag near the field device and oriented so that it is readable from the appropriate access location.

Labels longer than 30 mm shall have clearance fixing holes to allow differential expansion of label and mounting.

Where labels are mounted on standoffs they shall be suitably backed to prevent breakage.

Wording on labels shall be in capital block letters.

Wording is to be horizontal reading left to right.

Label letter height shall be generally as outlined in **Table 15: Label Letter Height**, Figure 1: Module Label and Figure 2: LCS Label 150mm x 30mm (130mm centres for mounting) below.

Table 15: Label Letter Height

Label	Letter Height (mm)
Switchboard Equipment Number	30
Switchboard Title	20
Compartment Module	See Figure 1 below
Device labels within an enclosure/compartment	3
Major Equipment (e.g. motors, instruments etc)	6
Minor Equipment	3
Pushbutton Designation	3.5
LCS	See Figure 2 below
Cables	3
Light and Power designations at the device	3
Ferrules	Brady style Ferrule labels

Figure 1: Module Label

Example information
Description: DIGESTER FEED PUMP No.1
Drive No.: MTR4213
Location: 1F-03 (cell reference, if applicable)
Schematic No.: KAWSTP-E-DR-4213-01
Rating: 22kW

Figure 2: LCS Label 150mm x 30mm (130mm centres for mounting)

Text Size:
Line 1: 10mm
Line 2: 6mm

All removable covers and protective shrouds which give access to exposed busbars or live terminals shall be labelled with red/white/red labels marked 'DANGER 415V ISOLATE ELSEWHERE'.

Equipment connected to the line side of a switchboard incoming switch (e.g. voltmeters) shall be marked "DANGER - LINE SIDE CONNECTION – ISOLATE ELSEWHERE".

Label lists shall be submitted to Unitywater for approval prior to manufacture.

A stainless steel label complying with this specification shall be fitted to the front of all LCS.

Pushbuttons and selector switches shall be labelled using proprietary legend plates or plastic labels complying with this specification.

Printed paper type labels will not be accepted.

16.2. Cables

All cables shall be identified at each end where they are connected to apparatus using stainless steel identification labels where the label is installed outdoors and plastic (Non-conductive) label when installed within a switchboard/indoors. The identification used shall correspond to that shown on the drawings or other design documents.

All stainless steel cable labelling shall be etched 316 stainless steel and fixed by appropriate means, i.e. stainless steel cable ties for external plant areas and appropriately tooled off (no sharp edges), nylon cable ties may be used for cable labels within buildings or enclosures.

All plastic (Non-conductive) cable labelling shall be Brady-style system or similar where a single printed marker is used.

Cables shall be labelled on both sides of a gland plate where both sides of the cable cannot be touched by one person at the same time.

Numbering ferrules shall be fitted to each end of all separate lengths of control and power wiring.

Ferrules shall have black letters on a background of white insulating material.

Cable cores including neutrals and earths shall be identified at each termination with approved full sleeve marker ferrules, numbered in accordance with the respective wiring diagrams.

16.3. Field equipment

Other field equipment will be labelled as per the requirements of this specification.

17. Appendices

Refer to the following pages.

Appendix A – Definitions/Acronyms

The following definitions, abbreviations and acronyms are used throughout this specification.

Term	Meaning
AC or ac	Alternating current
AHF	Active Harmonic Filter
ASME	American Society of Mechanical Engineers
ATS	Automatic Transfer Switch
CB	Circuit Breaker
Communications Cables	Fibre optic, Cat 6, Cat 5 etc Modbus
DC or dc	Direct current
DOL	Direct Online
Electrical Cables	All other types of cables not listed in Communication Cables, e.g. LV and ELV power and control cables
ELV	Extra Low Voltage (as defined in AS/NZS 3000)
EMI	Electromagnetic Interference
EPS	Expanded Polystyrene
HMI	Human Machine Interface
HRC	High Rupturing Capacity
IEC	International Electrotechnical Commission
IGBT	Insulated Gate Bipolar Transistor
kVAr	Kilo volt Ampere reactive
kW	Kilowatts
kWh	Kilowatt hours
LAN	Local Area Network
LCD	Liquid Crystal Display
LCS	Local Control Station
LED	Light Emitting Diode
LV	Low Voltage (as defined in AS/NZS 3000)
MCC	Motor Control Centre
MIMS	Mineral Insulated Metal Sheath
MVAC	Mechanical Ventilation in Air Conditioning Systems.
NATA	National Association of Testing Authorities
NDT	Non-Destructive Test
OIP	Operator Interface Panel
OT	Operational Technology
PFC	Power Factor Correction
PLC	Programmable Logic Controller
PVC	Polyvinyl Chloride
RFI	Radio Frequency Interference
RTD	Resistance Temperature Detectors
SCADA	Supervisory Control and Data Acquisition
SDI	Single Double Insulated
TDS	Total Dissolved Solids
TPS	Thermoplastic-sheathed cable
VSD	Variable Speed Drive

Term	Meaning
WS	Wiring System
WWTP	Wastewater Treatment Plant (also known as STP - Sewage Treatment Plant)
XLPE	Cross-Linked Polyethylene

Appendix B – References

General

All design, equipment and workmanship shall conform to the most recent requirements of relevant local, State and Commonwealth statutory requirements and applicable, current Australian Standards.

Where no Australian Standard exists, work shall conform to the most applicable, current IEC Standard.

Where conflict exists between different Codes, Standards or Regulations, the higher requirement shall apply.

Reference to specific clauses in other documents or codes is intended to highlight those points and shall not be taken to imply a lesser importance for all other applicable clauses.

All work shall conform to the Rules and Regulations of the Statutory Authorities having jurisdiction over the Site.

If the requirements of this Specification do not meet the minimum requirements of the statutory regulations and standards, the regulatory requirements shall apply.

If the requirements of the statutory regulations and standards do not meet the minimum requirements of this Specification, then this Specification shall apply.

Where deviation from this specification may improve the design, the designer may submit F10996 - Deviation to Unitywater Technical Specification to the Infrastructure Standards Team for consideration.

For general specification improvements, the online Unitywater Technical Specifications Improvement Request Form may be submitted to the Infrastructure Standards Team for consideration.

The following primary legislation and regulations apply in relation to this Specification:

- *Electricity Act 1994* (Qld)
- *Electricity Regulation 2006* (Qld)
- *Electrical Safety Act 2002* (Qld)
- *Electrical Safety Regulation 2013* (Qld)
- *Work Health and Safety Act 2011* (Qld)
- *Work Health and Safety Regulation 2011* (Qld)
- *Telecommunications Interception Act 2009* (Qld)
- *Telecommunications Act 1997* (Cth).

Relevant Unitywater documents that relate to this specification

Document No.	Title
F10678	Accepted Electrical Equipment List
F10996	Deviation to Unitywater Technical Specification to the Infrastructure Standards
Pr9846	SCADA and PLC Historian and Reporting[2] Specification
Pr9845	SCADA and PLC Implementation Specification
Pr9833	Specification for SCADA and PLC Architecture
Pr9844	Specification for SCADA and PLC Device Type - Siemens
Pr10434	Specification for SCADA and PLC Device Type - Siemens OPC
Pr10618	Specification for Power Systems Analysis
Pr9834	Specification for SCADA Standard
Pr9693	Standard Specification for Mechanical Installation
Pr10699	Treatment Plant PLC and SCADA Specification - Device Type Schneider PLC

International and Australian Standards referenced within this specification

Standard	Title
AS ISO 1000	The international system of units (SI) and its application
AS/NZS 1170.2	Structural design actions – Wind actions
AS 1202	Electronic imaging - Forms design optimization for electronic image management
AS 1375	Industrial fuel-fired appliances
AS/NZS 2053	Conduits and fittings for electrical installations – General requirements
AS 2293	Emergency escape lighting and exit signs for buildings
AS/NZS 2373	Electric cables - Twisted pair for control and protection circuits
AS/NZS 2729	Rolling bearings - Dynamic load ratings and rating life
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3008.1.1	Electrical installations – Selection of cables for alternating voltages up to 0.6/1kV-Typical Australian installation conditions
AS/NZS 3010	Electrical installations – Generating sets
AS/NZS 3013	Electrical installations – Classification of the fire and mechanical performance of wiring system elements
AS/NZS 3080	Information technology - Generic cabling for customer premises (ISO/IEC 11801:2011, MOD)
AS/NZS 3191	Electric flexible cords
AS/NZS 3439.1	Low-voltage switchgear and control gear assemblies – Type-tested and partially type-tested assemblies
AS 3715	Metal Finishing – Thermoset powder coatings for architectural applications
AS 3996	Access covers and grates
AS 4775	Emergency eyewash and shower equipment
AS/NZS 5000.1	Electric cables – Polymeric insulated – For working voltages up to and including 0.6/1 (1.2) kV
AS 60034	Rotating electrical machines

[2]*Reporting is ad hoc and site specific at present due to the inability to comply with Pr9846 - SCADA and PLC Historian and Reporting Specification. Future works will develop a reporting specification.*

Standard	Title
AS 60044.1	Instrument transformers – Current transformers (IEC 60044-1 Ed.1.2 (2003) MOD)
AS/NZS 60079	Explosive atmospheres
AS 60598.1	Luminaires –General requirements and tests (IEC 60598-1, Ed. 7.0 (2008) MOD
AS/NZS IEC 60947 series	Low-voltage switchgear and controlgear
AS 61347 series	Lamp controlgear
AS CA S009	Installation requirements for customer cabling (Wiring rules)
AS/NZS CISPR 11	Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement
AS/NZS CISPR 14.1	Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus Part 1: Emission
IEEE 519	IEEE Recommended Practice and Requirements for Harmonic Control in Electric Power Systems
IEEE C37.90.1	Surge Withstand Capability (Swc) Tests For Relays And Relay Systems Associated With Electric Power Apparatus
IEEE C 62.41.2	Practice on characterization of surges in low-voltage (1000 V and less) ac power circuits
IEEE 1584	IEEE Guide for Performing Arc-Flash Hazard Calculations
NFPA 70E	Standard for Electrical Safety in the Workplace