Hunter Water Corporation A.B.N. 46 228 513 446

Standard Technical Specification for:

STS 500

GENERAL REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

This Standard Technical Specification (STS) was developed by Hunter Water Corporation to be used in the design, construction or installation and maintenance of facilities that are, or are to become, the property of Hunter Water Corporation. It is intended that this STS be used in conjunction with various other standard and project specific drawings and design requirements as defined by Hunter Water Corporation for a particular project.

Hunter Water Corporation does not consider this STS suitable for use for any other purpose or in any other manner. Use of this STS for any other purpose or in any other manner is wholly at the user's risk.

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Standard – STS 500 General Requirements for Electrical Installations

1 Purpose

This standard technical specification (STS) details the requirements of Hunter Water Corporation (Hunter Water) for the design, manufacture, supply, installation, or modification of electrical equipment that is, or is to become, the property of Hunter Water.

2 Interpretation

For the purposes of interpreting *STS 500 General Requirements for Electrical Installations*, except where the context requires otherwise:

- 'drawings' means the drawings detailing the work involved in a particular project in hand
- ‘include’ means including but not limited to, and is used to provide clarification or examples of the type and nature of items intended
- 'specification' means a specification detailing the work involved in a particular project
- ‘Standards’ means applicable industry standards, including
    - Australian Standards (AS)
    - Australian/New Zealand Standards (AS/NZS)
    - American National Standards Institute (ANSI), and
    - International Organization for Standardization (ISO), referenced in Appendix A
- 'standard drawings' means Hunter Water drawings
- 'Standard Technical Specification' (STS) references any of Hunter Water’s standard technical specifications, as implied by the text.

Headings are for the convenience of the reader and shall not be used in the interpretation of this STS, nor limit compliance to other applicable sections of this STS.

Unless otherwise stated, any expression such as ‘give notice’, ‘submit’, ‘approval’, or ‘directed’ means give notice to, submit to, approval by, or directed by Hunter Water or its delegate.

Approval does not imply acceptance of responsibility by Hunter Water for compliance with this STS. Unless approval has been issued in writing, approval has not been granted.

Failure to comply with the requirements of this STS or any referred documentation may result in rejection. Where equipment or manufacture is rejected, notice will be given by Hunter Water in writing. All associated rectification work shall be completed by the contractor at their cost.

2.1 Order of precedence

Specific requirements, including those in project specifications or project drawings, take precedence over general electrical requirements in this STS.

Where a deviation from this STS is required to meet installation specific requirements, a request for dispensation must be submitted to Hunter Water. Approval in writing from the document owner must be obtained prior to proceeding with any deviation. All dispensation requests will be reviewed on a case-by-case, application/site specific basis by Hunter Water’s document owner.

3 Roles and responsibilities

3.1 Document owner

The document owner of this STS is Hunter Water's Group Manager Planning and Engineering.

3.2 Responsibilities

The document owner shall approve in writing the issue of any updated version of this STS.

Any concession to any requirement in this STS is valid only when authorised in writing by the document owner or their delegate.

4 Definitions

Dimensions indicated herein are in millimetres (mm), unless otherwise stated. Where the following term, abbreviation or expression occurs in this STS, it is defined as follows, unless the context implies otherwise.

Term, abbreviation, or expression	Definition
A	Amps
ACB	Air circuit breaker
Approval	Approved by Hunter Water
Approved	Included on a list prepared by Hunter Water of approved products and services
AHF	Active harmonic filter
AS	Australian Standard
AS/NZS	Australian/New Zealand Standard
BS	British Standard
CCEW	Certificate of Compliance for Electrical Work as defined by NSW Fair Trading
Consumer mains	Supply cable from supply authority point of connection or from the low voltage terminals of a Hunter Water substation to the main switchboard
Contract Manager	A person appointed by Hunter Water to act on behalf of the principal, as detailed in the Contract
Conformal coating	Protective chemical coating or polymer film 25-75µm thick (50µm typical) that 'conforms' to the circuit board topology. Its purpose is to protect electronic circuits from harsh environments that may contain moisture and/or chemical contaminants.
CT	Current transformer
Directed	Directed by Hunter Water or its Delegate
DNSP	Distributed Network Service Provider
DOL	Direct online
ELV	Extra low voltage
FAT	Factory acceptance test
FCL	Fault current limiter
FLC	Full load current

Term, abbreviation, or expression	Definition
FVC	Fused vacuum contactor
HD-PVC	Heavy duty PVC
HMI	Human-machine interface
HRC	High rupturing capacity
IDMTL	Inverse definite minimum time lag
IMCC	Intelligent motor control centre
Indicated	As specified or shown in the contract documents
IP rating	Degree of protection as described in *AS 1939*
ITC	Inspection test checklist
ITP	Inspection test plan
Large site	Large sites are generally treatment plants and large pumping stations with more than six pumps
LV	Low voltage
LPS	Lightning protection system
MCB	Miniature circuit breaker
MCCB	Moulded case circuit breaker
MCC	Motor control centre
MCR	Maximum continuous rating
MEN	Multiple earthed neutral (system)
MIMS	Mineral insulated metal sheathed (cable)
MSB	Main switchboard
OHEW	Overhead earth wire
OEM	Original equipment manufacturer
OPGW	Optical ground wire
Proprietary	A commercial supplier’s standard design of equipment or process

Term, abbreviation, or expression	Definition
PFC	Power factor correction
PLC	Programmable logic controller
PWM	Pulse width modulation
PVC	Polyvinylchloride
RCP	Remote control panel
RSTP	Remote spanning tree protocol
RTD	Resistive thermal device/resistance temperature detector (analog instrument)
SAT	Site acceptance test
SCA	Switchgear and control gear assembly
SCADA	Supervisory control and data acquisition. A control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management.
SLD	Single-line diagram
SPD	Service protective device
Spur	A radial section of the power distribution network
Submit	Submit to Hunter Water or its Delegate
Supply authority	The authority that supplies electricity to the locality of the project
Switchboard	A generic term used interchangeably that includes DBs, MCCs, MSBs, SCAs, remote I/O panels, LCPs, operator panels, marshalling cabinets, free- standing VSD, AHF, or similar electrical enclosure with hinged door. This definition is in addition to that contained within AS/NZS 3000.
TEFC	Totally enclosed, fan-cooled (motor)
THDi	Total harmonic distortion current
THDV	Total harmonic distortion voltage
TPI	Thermoplastic insulated
TPS	Thermoplastic sheathed
UPS	Uninterruptible power supply

Term, abbreviation, or expression	Definition
VCB	Vacuum circuit breaker
VSD	Variable speed drive
VT	Voltage transformer
Wet environment	Any of the following: • outdoor area • room containing pipework which contains liquid under pressure • area where equipment is located that requires wash down • area below natural ground level
Witness point	An opportunity provided to Hunter Water to witness an event. Notice is to be provided but work is not required to stop.
WPS	Water pumping station
WTP	Water treatment plant
WWPS	Wastewater pumping station
WWTW	Wastewater treatment works
XLPE	Cross linked polyethylene

5 General

5.1 Contractors

For the following works, use only contractors and sub-contractors listed on the approved contractors lists available on Hunter Water's website – www.hunterwater.com.au.

- electrical installation
- switchboard manufacture
- telemetry and automation

5.2 Materials and equipment

Select equipment and materials from the Approved Products and Manufacturers – Electrical list available on Hunter Water's website – www.hunterwater.com.au. All materials and equipment used shall be from items stocked within Australia and from local suppliers within the Newcastle region who provide support services for their products. All materials supplied shall be new and of the latest design.

Where suitable materials or equipment are not listed, submit full details of the proposed items and obtain written approval prior to use.

Where items are described by reference to a trade brand name or catalogue number, such a description is intended to indicate the type, quality, appearance and method of construction required. An item of a standard similar and equal thereto may be considered, subject to written approval from Hunter Water.

5.3 Standards of work

Except where *STS 500 General Requirements for Electrical Installations* and/or contract documents require a higher standard of work, all work shall be carried out in tradesman-like manner in accordance with the current edition of the nominated standards and regulations.

Where required, submit a test certificate from an independent testing authority as proof of compliance with a standard or specified test.

5.4 Designers

All electrical design works shall be reviewed and signed-off by a professionally qualified electrical engineer (bachelor degree or advanced diploma) with a least 10 years relevant electrical engineering experience including at least 5 years electrical design experience with proven competence in all areas of the electrical design work to be undertaken, all to the satisfaction of the Hunter Water's Manager Planning & Engineering - Electrical.

The designer shall be responsible to ensure that the design is technically competent and complies with the Regulations, Hunter Water design standards and the relevant terms of the engagement.

5.5 Performance of work

On-site electrical installation work shall be performed under the constant supervision of a person holding a Qualified Supervisor Certificate – Electrician, issued by the Department of Fair Trading, and a Hunter Water electrical induction.

5.6 DNSP Accreditation

Work that is subject to the supply authority's design, construction and installation standards shall only be performed by an accredited service provider. The service provider shall have the appropriate accreditation for the type and level of work being performed.

This work includes, but is not limited to:

- Designing electricity network assets.
- Extending or increasing the capacity of the electricity network.
- Relocating electrical network assets.
- Connecting new installations to the electricity network.
- Disconnecting redundant installations from the electricity network.
- Installing and energising service lines.
- Installing meters.

6 General design requirements, submissions, approvals and notifications

6.1 Detailed design report

A detailed design report shall be submitted for review and approval, and include documented evidence of compliance to all relevant standards.

All design submission requirements detailed in other sections within this STS that are relevant to the scope of the design works are to be included as part of the detailed design report.

The following, where relevant to the scope of the design works, shall be submitted as part of the detailed design report:

- Reference to any ASP3 contestable designs prepared as part of the works.
- Reference to any ASP3 private designs prepared as part of the works (6.4).
- Reference to all schedules prepared as part of the design (Refer Clause 6.2).
- Reference to all drawings sets prepared or modified as part of the design (Refer Clause 6.4).
- Switchboard user information template (Refer Clause 6.6).
- Cable sizing (Refer Clause 6.10).
- Cable installation conditions to comply with applied de-rating (Refer Clause 6.10).
- Safety system design (Refer Clause 6.13).
- HVAC assessment (Refer Clause 17.1).
- Generator sizing (Refer Clause 6.16).
- Short circuit study (Refer Clause 6.17).
- Protection study (Refer Clause 6.19).
- Arc flash study (Refer Clause 6.20).
- Lightning protection study (Refer Clause 8.1).
- Power quality calculations (Refer Clause 9).
- Power factor calculations (Refer Clause 9).
- AC UPS system design and calculations (Refer Clause 10.1)
- DC UPS system design and calculations (Refer Clause 11.1)
- DC power supply design and calculations (Refer Clause 12.1)
- Electronic drives design (Refer Clause 15.1).
- Switchroom HVAC, ventilation and lighting design (Refer Clause 17.1).
- Earthing design (Refer Clause 6.17).

6.2 Detailed design schedules

All required schedules associated with the design shall be submitted for review and approval.

All schedule submission requirements detailed in other sections within this STS that are relevant to the scope of the design works are to be included as part of the schedule submissions.

Where applicable the following schedules are to be submitted

- Cable schedule (Refer Clause 6.10).
- Conduit schedule (Refer Clause 6.11).
- Label schedule (Refer Clause 6.12).
- Maximum demand schedule (Refer Clause **Error! Reference source not found.**).

6.3 DNSP connection or modification

Submit to the DNSP for examination all information as requested by the Service and Installation Rules of New South Wales or the DNSP. Payment of all associated DNSP fees are the responsibility of the Consultant/Contractor.

Submit a copy of all comments provided by the DNSP and details of how the DNSP's comments have been addressed, a minimum of two weeks before construction of the switchboard commences.

6.3.1 Permanently unmetered supplies

The preferred DNSP connection is via a metered supply. The use of a permanently unmetered connection is subject to written approval by the Principal.

6.4 Private overhead lines and power poles

Where the works include the installation of Hunter Water privately owned overhead lines and power poles, the design must be performed by an ASP3 and must be designed to comply with the associated DNSP standards.

All private power poles must be labelled with a dedicated asset tag. A request for power pole asset numbers is to be made to Hunter Water.

Submit the design to the Principal for review and comment.

6.5 Electrical drawings

An electrical drawing package is to be submitted to support the electrical design. All electrical drawings shall be completed in accordance with *STS 904 – Preparation of Electrical Engineering Drawings*.

A request for the electrical drawing set number is to be made to Hunter Water at commencement of the project.

The submission of typical drawings is not acceptable.

6.5.1 Treatment plants

Example drawings are able to be provided for reference following a request to Hunter Water. The provision of example drawings shall not relieve the Contractor of complying with any aspect of *this STS*, or *STS 904*.

At treatment plant sites the drawing set shall include, but is not limited, the following drawings:

- Title page.
- Index sheets.
- Single line diagrams.
- Incoming power schematic diagrams.
- Generator and ATS schematic diagrams.
- 230 V a.c. UPS and non-UPS distribution.
- 24 V d.c. UPS and non-UPS distribution.
- Individual schematic diagrams for each motor starter and electric actuator (typical drawings are not acceptable).

- Individual termination diagrams for each motor starter and electric actuator (typical drawings are not acceptable).
- Instrument loop drawings for each instrument, including switches (typical drawings are not acceptable).
- Termination diagrams for all field marshalling panels and junction boxes that are associated with more than one instrument or piece of equipment.
- Control network architecture drawings (drawings are to be developed within the SK8198 set)
- PLC rack layouts.
- PLC I/O card schematics for each individual card.
- Fibre patching drawings.
- Dimensioned and to scale switchroom general arrangements showing all installed equipment and installation and maintenance clearances.
- Site electrical equipment and instrument layouts.
- Cable reticulation layouts including all underground conduits, cable pits and major cable ladder/tray runs. Layouts are to include cable pit dimensions, conduit quantities and conduit sizes. Note: cable reticulation layouts are to be integrated into the civil drawing package.
- Internal and external lighting layouts including individual lux levels for all areas and compliance/reference to the associated Australian standard. Include fittings make/models, quantities, pole details/heights, mounting angles, orientation and reference to the associated lighting circuit.
- Site general power layout including fitting location, type and reference to the associated power circuit.
- Switchboard general arrangements (refer Section 6.6).

6.5.2 Network sites

Prior to the preparation of any electrical drawings a request for the latest standard drawing set is to be made to Hunter Water. Where a standard drawing set is not available the drawings set shall comply with the requirements of Section 6.5.1.

The provision of a standard drawing set shall not relieve the Contractor of complying with any aspect of *this STS*, or *STS 904*.

6.6 General switchboard design

For each switchboard submit for review and approval the following:

Prior to manufacture commencing:

- Updated user information template (AS/NZS 61439.1 Annex C).
- Where switchboard manufacturers are assembling a proprietary verified switchboard, provide documentation verifying assembly accreditation from the original supplier.
- Detailed switchboard drawings to fully describe the switchboard being supplied. As a minimum this shall include:
    - Overall dimensioned layout (front top and side elevations).
    - Door opening direction and any outer and inner door/escutcheon detail.

  - Individual cell arrangements cross referenced to an equipment register that details the equipment make and model.
  - Construction material details, paint colour (internal and external), plinth specifications, mounting and lifting details, switchboard weight, and identification of sectional breaks.
  - full details and sizes of the consumers' mains and submains, and termination routes of these within the switchboard by means of dashed line.
  - details of all busbar and internal interconnecting cable sizes, spacing and configuration.
  - details of busbar support including materials, sizes, spacing, and fixing methods.
  - details of all internal segregation.
  - generator connection panel details including cable access, link bar size & mounting arrangement, link bar bolt details and cable supports.
- Design verification documentation for each verification characteristic as detailed with *AS/NZS 61439.1 Annex D*.
- Internal arcing fault verification documentation as required by section 0.
- Where the switchboard is to be mounted on a support frame submit detailed drawings of the frame, and certification/sign-off from a qualified structural engineer.

Post manufacture and prior to factory acceptance testing:

- Routine verification documentation for each characteristic as defined within *AS/NZS 61439.1*.
- Written confirmation the switchboard has been assembled, installed, tested, and connections have been made in accordance with *AS/NZS 61439* and this STS.

6.7 SCADA and automation

The design of SCADA and automation system components is to be in accordance with *STS 550 General Requirements for SCADA and Automation Systems*. The construction of panels shall be in accordance with this Specification.

Typical panels associated with the SCADA and automation system include:

1. Treatment Plants and other large sites

- SCADA network panel. Principal supplied free-standing proprietary 19-inch rack style enclosure that is required to be installed in all switchrooms. Panels shall include the following:
  - SCADA network switches/routers/firewalls, communications devices, optical fibre and CAT5e/6 terminations, and patch panels.
- PLC CPU/communications panel. Standalone indoor free-standing panel, located within 3m of the SCADA network cubicle. Panels shall include the following:
  - control network switches/routers/firewalls, communications devices, optical fibre and CAT5e/6 terminations, and patch panels.
  - control network telemetry devices.
  - PLC CPU main rack and communications modules.
  - no hardwired PLC I/O shall be in this cubicle.
- PLC I/O cubicle. Dedicated cubicle integral to switchboards, MCCs and standalone remote PLC I/O cubicles. Panels shall include the following:

- control network switches, communications devices, optical fibre and CAT5e/6 terminations, and patch panels.
- PLC remote I/O rack and communications modules.
- hardwired PLC I/O modules.
- interface relays and terminals for hardwired PLC I/O.

Any PLC I/O on treatment plants or large sites that is located outside of the switchrooms or attached buildings, shall be terminated into standalone remote PLC I/O rack cubicles on the control network rather than direct hardwiring back to PLC I/O in the switchrooms.

2. Network Sites

- PLC CPU/communications and PLC I/O panel. Dedicated cubicle integral to the site switchboard. Panels shall include the following:
  - control network switches, communications devices, optical fibre and CAT5e/6 terminations, and patch panels.
  - control network telemetry devices.
  - PLC CPU main rack and communications modules.
  - hardwired PLC I/O modules.
  - interface relays and terminals for hardwired PLC I/O.
- Standalone remote PLC I/O cubicle. May be required for processes where PLC I/O is concentrated remotely from the PLC CPU, for example, reservoir chlorinators. Configuration and equipment is as per treatment plants and other large sites.

All SCADA and automation system panels are to include:

- Specific equipment as defined within STS 550 General Requirements for SCADA and Automation Systems.
- Double 230 V a.c. 10A socket outlet. For treatment plant switchboards the outlet shall be supplied from a UPS and shall be coloured red.
- Power supply from UPS backed supply.
- Minimum 20% spare space.
- In addition to the previous dot point, where a PLC I/O rack is installed within the cubicle, allow 20% spare slot space within the PLC rack plus adequate space to accommodate the future field wiring and terminals of all spare slots.
- Any further requirements detailed within this Specification.

6.8 UPS systems and battery autonomy times

UPS systems are installed to uphold critical control and monitoring equipment during a power failure scenario. Both a.c. UPS and d.c. UPS systems are used at Hunter Water sites to achieve the required site autonomy (backup) time, with the selection dependent on the site type.

The UPS type shall be selected in accordance with the following table:

UPS Type	**Site Type**
a.c. UPS	ICT (e.g. server rooms)

	Treatment plants Radio bases Sites requiring low voltage UPS backup
d.c. UPS	Network sites* (e.g. WPS, WWPS, BPS, reservoirs, flowmeters, PRV etc.). *where a site cannot achieve the required autonomy using a d.c. UPS an a.c. UPS shall be provided.

UPS systems are to be sized to achieve the following minimum site autonomy times:

- Treatment plants 4 hours
- Radio bases 12 hours
- Reservoir outstations 12 hours
- Non-reservoir outstations 4 hours

Refer to the respective a.c UPS and d.c. UPS sections of this STS for additional requirements, including specific loads to be supplied via the UPS system.

6.9 Remote circuit breaker operation

Remote operation of circuit breakers shall be provided as follows:

- All circuit breakers that have a hazard risk category exceeding CAT 2.
- All circuit breakers rated 1600A and above.
- All kiosk transformer and high voltage ring main unit circuit breakers owned and operated by Hunter Water.

Hunter Water currently has the following two types of remote control panel in use across their network:

- HMI remote control panels.
- Hardwired remote control panels.

The remote control panel type is subject to Hunter Water approval and will be dependent on site specific installation conditions.

6.10 Cable sizing and schedules

Cable sizing calculations and cable schedules shall be developed and submitted for review.

All cabling shall be designed in accordance with AS/NZS 3000 and AS/NZS 3008.1 series. Cable sizing and selection must be performed using a proprietary software program. The modelling of each circuit must include the installed circuit protective device with the settings adjusted to suit the selectivity study. Where the specific circuit protective device is not available an alternative protective device with an equivalent time current curve may be used.

Each cable schedule shall be developed using Excel and have a file name which is a drawing number related to the installation. Cable schedules shall include all cables including light and power, optical fibre,

communications, security alarms and fire systems. Cable schedules shall have, as a minimum, the following column headings:

- cable number
- from drive/service
- to drive/service
- termination diagram drawing dumber
- number of cores
- core size in CSA (mm2)
- cable type e.g. Cu XLPE/PVC
- estimated length
- AS/NZS 3008 installation condition (e.g. in-air enclosed, in-air unenclosed, buried direct in ground, underground wiring enclosure etc.).
- maximum number of circuits to comply with design derating (e.g. number of circuits per tier or row, number of circuits/cables in underground wiring enclosure)
- comments

Note: for cable schedules that are integral to the standard Hunter Water drawing sets, a separate excel schedule is not required to be developed. In this case the design report must clearly identify any cable installation conditions that are to be adhered to in order to comply with the applied cable derating factors.

6.11 Conduit schedules

Conduit schedules shall be submitted for review (Note: excludes network pump stations with no other assets e.g. chemical dosing). Each conduit schedule shall be developed using Excel and have a file name which is a drawing number related to the installation. Conduit schedules shall have, as a minimum, the following column headings:

3. conduit number
4. from pit/location
5. to pit/location
6. conduit diagram drawing number
7. conduit size
8. cables installed in conduit
9. % conduit capacity used in accordance with AS/NZS 3000 space factor
10. estimated length
11. comments

6.12 Label schedules

A full schedule of labels shall be developed and submitted for review. Each label schedule shall be developed using Excel. For more information on labelling requirements refer to Section 16.3.

Each label shall clearly show:

- material of manufacture
- background colour
- text colour
- text size
- font
- label dimension
- notes on intended location of installation (e.g. main switch room door – external)

6.13 Safety system design and emergency stops

It shall be the Contractor's responsibility to ensure that the motor controls for all equipment provided are of the appropriate safety category rating and in accordance with all machine guarding requirements of *AS/NZS 4024*.

Safety systems incorporating emergency stops shall not be installed for the protection of equipment. Written request for exemption shall be submitted to the Principal if a safety system incorporating an emergency stop is requested for equipment protection.

A risk assessment shall be completed in accordance with *AS/NZS 4024* to determine if a safety system design is required to mitigate against unacceptable safety risks to personnel. The risk assessment shall be undertaken in consideration of the physical arrangement of the equipment and include reference to drawings, OEM documentation, power supply configuration and accident history.

Where the risk assessment identifies additional control/protection is required, prepare a safety system design in accordance with the following minimum requirements:

- compliance with *AS/NZS 4024.*
- regardless of the safety category determined by the risk assessment all safety systems shall be designed to include a proprietary safety relay i.e. Cat B, Cat 1 & Cat 2 systems shall include a safety relay.
- local manual reset of the safety circuit via a pushbutton on the local control panel.
- safety circuit unhealthy indicator on the local control panel. Note the indicator is to be self-resetting and therefore only remain active whilst the safety circuit condition is active.
- safety relay shall be UPS backed to ensure a reset is not required following a local or sitewide power outage.
- the safety circuit shall not be able to be bypassed.

The following safety system design information shall be submitted for review:

- overview of all motors included as part of the risk assessment process.
- risk assessment documentation identifying the limits/ boundaries of the motor. Note a common risk assessment for specific installation arrangements is acceptable e.g. submersible pumps in wet wells.
- documentation verifying compliance with the required safety category for all safety system equipment (e.g. safety relay, limit switches, emergency stops etc.).
- design drawings.
- validation documentation following system commissioning.

6.14 Radio path survey and telemetry antennas

Where required, all radio path surveys shall be performed by Hunter Water. A request for a radio path survey is to be made by the Contractor to the Principal.

A dedicated minimum 8m high telemetry mast is to be provided for mounting of the antenna. The mast is to be free-standing and therefore not supported off the switchboard or other structures e.g. vent stack. The final height of the telemetry mast shall be determined by the radio path survey.

The pole material is to be hot dipped galvanised. Timber poles shall be considered for pole heights above 8m and where additional lightning protection measures are required following the site lightning risk assessment. The pole material is subject to Principal approval.

The structural rating of the pole and footing is to be suitable for the environmental conditions and loads of installed equipment. Submit detailed structural drawings and certification.

6.15 Legacy MCC control circuit voltages

The addition or replacement of a starter within a switchboard with existing 230 V a.c. control circuits shall trigger the upgrade of all starters in the switchboard to 24 V d.c. control.

Prior to commencing the design consult with the Principal to confirm the minimum upgrade requirements.

6.16 Generator sizing

Permanent and temporary connected generators must be sized to accommodate the following:

- Site maximum demand including future loads.
- Motor starting currents in consideration of the site automatic and manual control requirements.
- Harmonics.

Generator sizing calculations shall be submitted for review.

6.17 Earthing design/study

An earthing design must be provided for each project. The earthing design is to include:

- Commentary on the AS/NZS 3000 compliance of the earthing and equipotential bonding system.
- Any site specific earthing requirements associated with the works.

A detailed earthing study is to be submitted for review where a direct lightning strike earthing system is required following the completion of the lightning risk assessment. The study shall include as a minimum:

- Soil resistivity test results.
- Calculations.
- Design drawings detailing the physical location, installation requirements and specification of all earthing system components.

6.18 Short circuit study

A short circuit study shall be completed for the following:

- New designs.

- Modification or upgrade works that result in a change to the prospective short circuit current at any point in the power distribution system.

The short circuit analysis shall include the following tasks as a minimum:

- Submission of a site fault level request with the DNSP, including payment of any associated fees.
- Investigation and verification of site cable data required to complete the study.
- Calculation of the maximum and minimum rms three phase short circuit current at each switchboard (e.g. MSB, MCC's, DB's etc.) in accordance with the latest version of *IEC 60909 / AS 3851*.
- Include motor short contribution in accordance with AS 3851 for all motor starter types that permit the contribution of current during an upstream short circuit fault. Where more than one motor is installed at an individual site consult the Principal to confirm the implemented control method (duty/assist, duty/standby etc.).

Note: Only switchboards with a short circuit rating that will be impacted by the works are required to be included within the short circuit study (i.e. a minor modification on a treatment plant switchboard is not intended to trigger a short circuit study for switchboards at the site that are not impacted by the works).

The following shall be submitted to the Principal as part of the short circuit study report:

- DNSP site fault level data.
- Input equipment and circuit data including:
    - Transformers – kVA rating, impedance, and X/R ratio. Note only required for HWC privately owned transformers.
    - Motors – kW rating, FLC, LRC. Only required where motor contribution is applicable.
    - Conductors – Insulation type, no. of conductors, length, size.
- Maximum and minimum rms three phase current at each switchboard. Results shall be presented in either a tabular format or on a single line diagram.
- Details on any assumptions made as part of the study.
- Recommendations for switchboard and equipment short circuit ratings based on the results of the study.

6.19 Protection study

A protection study shall be completed for the following:

- New designs.
- Modification or upgrade works that include new circuit breakers and/or changes to existing circuit protection settings .

The study shall adhere to the following requirements:

- Demonstrate compliance of the design with *AS/NZS 3000* selectivity requirements.
- Protection settings are to be selected with the aim of achieving the lowest possible instantaneous settings without jeopardising circuit availability.
- Protection study shall include all low voltage circuit breakers and fuses impacted by the works.

The protection study is to be completed using the following method:

- Manufacturer's circuit breaker selectivity and cascading documentation, or where this is not achievable:
- Software modelling via manufacturer time-current curves, or where time-current curves are not available:
- Adoption of the selectivity ratings defined within *AS/NZS 3000*.

The following shall be submitted to the Principal as part of the short circuit study report:

- Overview of the method that has been selected to perform the protection study and justification of the suitability of this method in achieving *AS/NZS 3000* compliance.
- OEM data, time-current curves or *AS/NZS 3000* selectivity rating calculations as applicable.
- Details on any assumptions made as part of the study.

6.20 Arc flash study

An arc flash study shall be completed for any new switchboard design, modification or upgrade. The study shall adhere to the following requirements:

- Comply with the requirements stipulated in the latest version of *IEEE 1584*.
- Include modelling of the maximum and minimum arc fault currents, including the future maximum arc fault current where a future maximum short circuit current has been supplied by the DNSP.
- Include the line and load side of all switchboard incomer circuit protection devices and isolators including but not limited to main switchboards, MCC's and DB's.
- A maximum of 2 second clearing time, for personal protection, shall be used in arc flash incident energy level calculations.
- The HRC category shall not exceed CAT 2 where practicable.
- Where the arc flash category exceeds CAT 2 the designer is to investigate options for reducing the level below CAT 2. Options to be investigated shall include:
    - Replacement of the protection device.
    - Modification of protection device settings.
    - Installation of an upstream current limiting device.

  Where the above options are unable to reduce the level below CAT 2 other engineering controls shall be implemented e.g. remote switching.
- Arc flash studies for generator connection points, not inclusive of onsite fixed generation, shall be excluded.

An arc flash report shall be submitted with the study. The report shall include:

- DNSP fault level data.
- Results of the arc flash study in tabular form including the following information for each bus system:
    - Protective device name
    - Bus voltage (kV)
    - Bus bolted fault (kA)
    - Motor contribution (kA)
    - Bus arcing fault (kA)
    - Protection device bolted fault (kA)
    - Protection device arcing fault (kA)
    - Trip/delay time (sec)
    - Breaker opening time (sec)
    - Electrode configuration (VCB, VCBB, HCB, VOA, HOA).
    - Box width, height, and depth (mm).
    - Electrode gap (mm)
    - Arc flash boundary (mm)
    - Working distance (mm)
    - Incident energy (cal/cm^2) at the working distance
    - PPE level .
    - (Category 0 to 4).
- Details on any assumptions made as part of the study.

- Review of the arc flash study results and where applicable recommendations to reduce the arc flash boundaries for existing installations.
- The arc flash sticker details in accordance with the following example

6.21 Maximum demand

Maximum demand calculations shall be completed for the following:

- New designs.
- Modification or upgrade works that impact the switchboard full load current.
- Where required to support the DNSP application.

Maximum demand calculations shall be developed in accordance with *AS/NZS 3000* and the specific requirements noted within this clause.

Maximum demand calculations shall be developed in Microsoft Excel and provided as part of the detailed design report. Proprietary software packages may be used to develop the site maximum demand where the minimum requirements below are satisfied.

The maximum demand shall include as a minimum:

- Description of each individual connected load.
- Motor starting type e.g. DOL, VSD, soft-start
- Nameplate motor kW rating.
- Nameplate motor kVA rating.
- Nameplate motor power factor.
- Nameplate motor full load current.
- Duty status (e.g. duty, assist, standby).
- Duty kW rating (% of kW rating).
- Duty kW rating.
- Duty kVA rating.
- Duty power factor.
- Duty motor full load current.
- Duty cycle (operating hours per day) – Treatment plants only.
- kWh/year – Treatment plants only.
- Total maximum demand (Amps, kVA)

The following notes apply to the preparation of the maximum demand:

- Supporting evidence is to be supplied where a reduced duty load is applied e.g. pump duty curves, VSD OEM power factor data.
- Where pumps are selected to achieve an increased flow rate in the future, but operate at a lower flow rate initially, the maximum demand shall be calculated based on the future pump duty point.
- The use of generic motor ratings (e.g. kW, kVA, power factor, FLC) shall only be acceptable for projects at the concept design stage.
- At the concept design stage, the total site maximum demand shall include a suitable contingency factor which is subject to Principal approval.
- AS/NZS 3000 diversity factors are only to be applied to general light and power loads. The application of a diversity factor to any other load is subject to Principal approval.

6.21.1 **Treatment plants**

At treatment plant sites the maximum demand is to be developed in consideration of the plants process requirements based on the worst case operating scenario.

Where the maximum demand is used to support a DNSP power supply connection application the designer shall include a minimum 20% contingency factor, which is subject to Principal approval, for future additional loads.

6.21.1 **Pump stations**

The maximum demand for pumping stations with one or two pumps installed shall be based on all pumps running simultaneously at 100% load, plus auxiliaries.

Unless required otherwise by a specific installation, the maximum demand for pumping stations with more than two pumps installed shall be based on one fewer than the total number of pumps to be installed running simultaneously, plus auxiliaries.

6.22 Consumer mains

The maximum voltage drop in consumers' mains at treatment plants shall not exceed two percent (2%). For all other sites comply with *AS/NZS 3000*.

Consumer mains may be either copper or aluminium. Where aluminium cable is proposed it shall be:

- Single core, 0.6/1kV X-90 insulated, PVC sheathed to AS/NZS 5000.1, and manufactured to PVC Best Practice Guidelines.
- Terminated using proprietary bi-metallic lugs in accordance with the manufacturer's recommendations.

6.23 Switchboards supplied by two or more transformers

The MEN is to be located at the transformer to aid earth-fault protection where Hunter Water is a HV metered customer. In other scenarios the location is to be negotiated with the DNSP and Hunter Water.

Where a bus-tie is installed it shall be 4 pole.

Key-interlocking shall be provided if the switchboard is not rated for the full fault current of all connected transformers operating in parallel.

6.24 Control of equipment

All electrical equipment shall be supplied from a plant switchboard and controlled via the site PLC.

6.25 Packaged plants

The use of package plants is subject to approval by the Principal.

Package plants that include a proprietary switchboard shall be acceptable only if they conform to the switchboard construction requirements of this STS (refer Section 16), in particular colour coding of cables.

Package plant switchboards are to be installed within a switchroom. The installation of package plant switchboards outside of a switchroom is subject to approval by the Principal.

For all packaged plants that are expected to use 35,000 kWh per year or more, provide a signal which corresponds to the instantaneous kW used. Use power meters, electronic motor protection relays or controllers for packaged plants to provide this signal.

7 Earthing

7.1 Witness points

Connection of earth cables to concrete reinforcing prior to pouring.

7.2 General

All portions of the installation shall be considered an ‘earthed situation’ as defined in *AS/NZS 3000*. Any exposed metal on the equipment shall be earthed in accordance with the requirements of *AS/NZS 3000* and those of the DNSP.

The earthing system shall comprise the multiple earthed neutral (MEN) system.

Where Hunter Water owns multiple distribution transformers that supply a switchboard, the MEN shall be located at the transformer.

Where the installation is to be in a switchroom an equipotential earth bar shall be wall mounted above the floor level, preferably in a corner, and clearly labelled. All equipotential earths associated with the switchroom are to terminate at the equipotential earth bar, with a single earth connection point provided to the switchboard earth bar. For installations which do not have a switchroom all earths shall be terminated to the switchboard earth bar in accordance with *AS/NZS 3000*.

All earth cables shall be uniquely identified with a cable tag, with the same number appearing at both ends of the cable. All earth cables shall be captured on the cable schedule and where appropriate detailed within the electrical drawings.

All metallic stands and structures that have electrical equipment mounted on them shall be equipotential bonded to earth using an appropriately sized earth conductor in accordance with the requirements of *AS/NZS 3000.*

All metal to be earthed shall be connected from an earth terminal directly to the earth bar or link with an electrically continuous copper conductor.

7.3 Equipment earthing

The earthing connections shall be such that removal of one component shall not affect continuity of the earthing conductor associated with any other equipment.

All powered equipment, such as power supplies, PLC racks and electronic starters, remote I/O and instrument panels shall be earthed directly to the MCC earth bar with suitably rated copper conductors. Special requirements exist for VSDs.

Metal frames of fuse switches and circuit breakers shall be connected to the earth bar. The earthing cable shall be a suitable size for the particular switch or circuit breaker.

Earthing components by means of mounting fastening is not acceptable.

7.4 Earth electrode pits

Earth electrodes shall be installed complete with pit and cover. The connection point shall be no greater than 50mm below the lid for the connection point to be readily accessible.

A pit shall be provided around the top 250mm of the earth electrode.

The lid shall be installed such that it is flush with the ground surface or aggregate, and secured so as not to cause a trip hazard.

The pit lid shall include provision for easy removal by tool. If special tools are required, a minimum of two (2) lid removal tools shall be supplied to the principal per site upon the completion of the installation.

Pits shall be labelled with electrode identification. Labels shall be grade 316 stainless steel or brass. Letters shall be minimum 10mm in height.

7.5 Earth electrodes for low voltage supplies

- Earth electrodes shall be copper clad steel.
- For supplies up to 100A the electrode shall be a minimum of 12mm diameter, driven to a minimum depth of 1200mm.
- For supplies above 100A the earth electrodes shall be a minimum of 19mm diameter, driven to a minimum depth of 1800mm.
- If rock is encountered, then horizontal installation is permitted in accordance with *AS/NZS 3000*.
- The main earthing conductor shall be connected via CAD welding or 'C' Crimp to the earth electrode.
- Electrodes shall be a proprietary product and fit for purpose.
- The main earthing conductor shall be installed and labelled as per *AS/NZS 3000*.

7.6 Functional earthing

Where equipment requires a functional earth to be connected for the purposes of correct operation, a functional earth bar shall be installed in accordance with *AS/NZS 3000*. The functional earth bar shall be insulated and connected to the main earth bar via a single 6mm2 earth cable.

Note instrument cable screens are not considered a functional earth and therefore are not required to be connected to the functional earth bar. Refer to section 8.2.1 for instrument cable screen termination requirements.

7.7 Structural reinforcement earthing

All concrete structures that have electrical equipment operating above ELV installed on them (e.g. plinths, transformer pads, switchroom floors, local control panel support pads, pump pads etc.) shall have the steel reinforcement connected to the site earthing system.

Concrete structure earthing shall adhere to the following:

- Have a continuous weld of the reinforcing around the perimeter of the structure to maximise current dispersal. Where this cannot be achieved by design, bonding straps and additional earthing connections are required.
- Have welded connections between reinforcement layers to ensure continuity.
- A minimum of two (2) diagonally opposite external earth connection points are to be installed on concrete structures with a surface area greater than $20m^2$ to allow the steel reinforcing to be connected to the earthing system.

- The connection of the reinforcement to the external earth connection point shall be a made via proprietary commercial bonding system (e.g. Dulmison Type C70, Sicame Wetcon or similar).
- Connection points shall be clearly labelled in the field and identified on the earthing system drawings.
- The external earth connection point shall be provided with easily removable mechanical protection.

7.8 Earthing of variable speed drives

Refer to Section 15 Electronic drives.

8 Lightning & surge protection

8.1 Lightning protection

8.1.1 Risk assessment

An *AS/NZS 1768* lightning protection risk assessment is to be undertaken for all new structures in order to determine the need for direct strike protection. Note a free-standing outdoor switchboard associated with a sewer pump station is not considered a structure and is not required to be assessed.

The results of the lightning protection risk assessment are to be submitted as part of the lightning protection study.

8.1.2 Design

Where the risk assessment process identifies the need for direct strike protection of a structure, a lightning protection system (LPS) design is to be completed in accordance with AS/NZS 1768. The lightning protection design shall achieve a PL II protection level as per *AS/NZS 1768*, and consider transfer potential where appropriate.

The LPS earthing system design is to be completed using specific soil resistivity test results for the installation area in lieu of typical values.

The lightning protection system design is to be submitted as part of the lightning protection study.

8.2 Surge Protection

The function of the surge protection device is to provide protection against transient over voltages associated with direct (conduction) and indirect (induction) surges.

The design intent is to provide a coordinated surge protection installation such that during a surge event the residual voltage is less than the impulse withstand voltage of the downstream equipment being protected (e.g. switchgear and electronic equipment).

8.2.1 Low voltage surge protection

The selection and installation of low voltage surge protection equipment is to comply with the following, as a minimum.

Surge protection devices shall:

- Comply with the testing protocols of *IEC 61643-11* in order to verify all performance values quoted, with test certificates available to verify such testing.
- Be installed in accordance with the *AS 4070* and the manufacturer's recommendations with strict compliance to the maximum length of connections, installation "as straight as practicable", and minimum 6mm2 cable size.
- Be shunt connected.
- Control, signal and communication surge protection devices shall be inline connected.
- Be installed with gG HRC backup fuse protection sized in accordance with the manufacturer's recommendations.

- Include L-N, L-E, N-E protection modes.
- Include a fail-safe fault contact wired to PLC to monitor the condition of the surge diverter.

As a minimum SPD's are to be rated and installed at the following locations:

SPD Rating	**Location**
AS/NZS 1768 Category C3 (100kA I_{max}) + *IEC 61643-11* T1 (25kA I_{imp})	Main switchboard, and/or first switchboard within a building fed by long overhead lines. Note where sensitive electronic equipment is installed within the switchboards include additional protection as per the below line item.
AS/NZS 1768 Category C1 (40kA I_{max}) + *IEC 61643-11* T2	All switchboards (e.g. MCC's, DB's, remote I/O panels etc.) with exception of the following: • Switchboards covered in the above line item. • Switchboards directly supplied from an upstream switchboard that is located in the same switchroom and has a category C1 surge protection unit installed.
AS/NZS 1768 Category A (10kA I_{max}) + *IEC 61643-11* T2/T3	Field end of power wiring to instrumentation or electronic equipment that runs external to a building (e.g. analysers, flow meter transmitters, auto-samplers).

8.2.2 Control, signal and communication surge protection

The selection and installation of control, instrument and communication surge protection equipment is to comply with the following, as a minimum.

Surge protection devices shall:

- Comply with *AS/NZS 1768.*
- Be series connected gas discharge (GDT) type.
- Provide common and differential mode protection.
- Fail safe (open) operation.
- Be installed in accordance with manufacturers recommendations.
- Have a minimum discharge current of:

- 5kA (8/20µs) or greater for control and instrument protection.
- 20kA (8/20µs) for radio antenna protection.

As a minimum, surge protection devices are to be installed at the following locations:

- Switchboard end of all PLC I/O and ELV power wiring that is installed external to a building.
- Field end of analogue instrument wiring that is installed external to a building.
- Field end of ELV power and control wiring to electronic instrumentation or equipment, that is installed (runs) external to a building.
- Control and signal wiring connected to electronic starters (e.g. VSD, soft starter etc.) or electronic overloads (e.g. Tesys T) that is installed external to a building.
- Switchboard end of antenna cabling.

The connection and earthing of instrument screens through surge protection devices shall comply with the following:

- Unless required by the design and/or manufacturers requirements, the earthing of screens shall be performed directly to the DIN rail through a grounded surge protection base at the switchboard end only.
- Isolated surge protection device bases are to be used in the field in order to allow continuation of the screen whilst ensuring single point grounding at the switchboard end in accordance with the above clause.
- All DIN rails with surge protection devices mounted on them shall have a 6mm2 earth connected directly to the earth bar via a dedicated earth terminal.

9 Power quality

9.1 Submissions

The following reports shall be submitted as part of the detailed design report:

- THDV calculations
- THDi calculations
- Power factor calculations

9.2 Total harmonic distortion (THD)

Design electrical systems to comply with the requirements as set down in *AS/NZS 61000*. In addition to these requirements, THDv shall not exceed five percent (5%) or the DNSP's negotiated connection offer, whichever is lower, at the DNSP point of connection or Hunter Water facility's substation transformer secondary terminal.

Where the desktop study identifies that active harmonic correction is required, arrange a meeting with the Principal to determine the preferred path forward.

Where AHFs are required, the additional heat loading from the AHF shall be incorporated into the total heat loading of switchboards and switch rooms. Any heat loading above Hunter Water's specifications shall be mitigated by additional cooling, venting, relocation, or other method approved by the Principal. Heat loading from AHF shall be calculated at 100% AHF output capacity.

9.3 Power factor correction (PFC)

The electrical system shall be designed to maintain the site power factor above 0.9 lagging in accordance with the *Service and Installation Rules of New South Wales (NSW SIR)*. Where the design calculations show the site power factor will not meet the NSW SIR requirements then power factor correction equipment shall be installed.

PFC equipment shall:

- Be designed to achieve a minimum power factor of 0.95 lagging.
- Be installed in a separate enclosure. Note where a PFC unit is installed within a switch room, it shall be physically separated from the associated MSB or MCC.
- Be fitted with tuned reactors that comply with the *Service and Installation Rules of New South Wales*.
- Have all capacitors rated to 525V minimum.
- Include anti-harmonic reactors with Class F insulation, a rated current of at least 1.25 times the rated capacitor current, and designed to carry 1.5 times the rated capacitor current without saturating.
- Have each step tuned to a frequency of 189Hz to prevent resonance and to block currents of the fifth harmonic and above.

In addition, for installations greater than 100A switchboards, the PFC equipment shall:

- Comprise modular capacitor steps with protection and associated switching devices, which shall be switched by an automatic programmable controller. Alternatively, on pump station sites with

capacitor banks installed on individual pumps an alternative control arrangement may be used subject to written approval from the Principal.

- Be totally isolated by the PFC main switch.
- Automatically disconnect all capacitors in the event of power failure, with automatic switching restored on resumption of power after an adjustable time delay.
- Be provided with ventilation that incorporates a fan and filter with thermostat control. Rating of the fan and air circulation shall be provided to power factor equipment vendors' recommendations.
- Be provided with over-temperature protection via a temperature monitoring switch. The switch shall activate a PLC alarm output above 550°C, or the OEM recommended temperature limit, and disconnect the power factor correction system.

Configure and program the local SCADA and HMI and send to Head Office SCADA the following information:

- Power factor monitoring.
- KVAR monitoring.
- Capacitor units faulted/healthy status.
- Over-temperature protection alarm.

10 A.C. UPS systems

10.1 Submissions

The following shall be submitted as part of the detailed design report:

- UPS maximum demand including detail of all connected loads and spare capacity requirements.
- Calculations and/or documentation to support the UPS sizing, including any applicable derating to suit the installation environment.
- Calculations and/or documentation to support the UPS battery sizing, and in particular compliance with the required autonomy time and derating factors.
- Calculations and/or documentation to support the UPS recharge timeframe.
- Calculations and/or documentation to verify the suitability off the UPS to withstand the maximum fault current level at the UPS input terminals.
- UPS and battery system certificates of compliance to *AS 62040.1 and AS 62040.2.*
- UPS and battery system specifications including short-circuit current and maximum d.c. voltage.
- Enclosure ventilation calculations to *AS 2676.2* or *AS/NZS 5139*.
- Assessment of the suitability of the building ventilation system in consideration of the ventilation calculations.
- Arc flash assessment in accordance with *AS/NZS 5139.*
- Installation risk assessment.
- Label and safety signage schedule including installation locations.
- Dimensioned general arrangement drawing showing the UPS location, door opening clearance, any additional clearance requirements as required by the OEM, *AS/NZS 3011.2* and *AS/NZS 5139*.
- UPS and battery system OEM technical datasheets.
- Bypass switch OEM technical datasheets.
- Enclosure OEM technical datasheets.

10.2 General

Uninterruptable power supplies (UPS) and battery systems shall be designed and manufactured to *AS 62040.1* and *AS 62040.2*.

The supply of a custom manufactured battery system is subject to written Principal approval.

UPS and battery systems shall be minimum IP2x.

The UPS unit shall supply, as a minimum, the following equipment:

- SCADA servers
- SCADA and control network switches
- Firewalls
- Control network gateways and media converters
- PLC hardware
- HMIs
- Routers, modems and RTUs
- Instrumentation critical to the monitoring and/or control of an asset
- Instrumentation that requires manual start up on energisation

- Safety systems that requires manual reset following power loss
- VSDs and electronic overloads

Depending on the equipment voltage rating the UPS may either supply it directly at 230 V a.c., or via a redundant 24 V d.c. power supply system (refer section 12 D.C. power supplies).

10.3 Capacity

Size the UPS for the load imposed by all connected equipment plus 30% additional capacity. UPS sizing shall consider motor starting currents as required.

Include unity power factor battery capacity to achieve the autonomy times detailed within Section 6.8 for the load imposed by all connected equipment plus 30% additional capacity.

The UPS battery shall be sized in accordance with the following minimum requirements:

- Minimum 1.75 end point volts/cell
- 10 year design life with 25% ageing derating factor
- Derating to accommodate UPS efficiency

The UPS and battery sizing is to be designed to achieve recharge to a 90% capacity within 24hrs.

10.4 Performance

The UPS performance is to be equal to or better than the following:

- output voltage 230 V a.c. ±1%
- total harmonic distortion <5%
- output frequency 50Hz ±1 Hz
- maximum rate of frequency drift 0.1Hz/second
- overload capacity 125% for 10 minutes
- dynamic load response ≤ 40ms
- output power factor 1
- Output performance classification VFI-SS-111 (according to IEC62040–3)
- audible noise <60dB(A) as per *AS 2107*

10.5 Alarms

The UPS shall have the following alarms connected to the PLC for monitoring on the SCADA:

- UPS unit failure
- battery fault (common fault to activate on failure of a single battery string/unit)
- buffering

Alarm must be fail safe in function, as to ensure alarms are raised when mains power is not available.

10.6 Batteries

Batteries shall be installed within a proprietary battery enclosure that complies with *AS 62040*, and includes associated certification documentation.

Batteries shall be gel, sealed lead/acid recombination type or lithium, and shall be constructed in accordance with the applicable Australian Standard at the time of manufacture, or IEC standard where an Australian standard does not exist.

Individual battery units shall be connected to the UPS using proprietary plug-socket connections. Where the installation of more than one battery unit is necessary to achieve the required autonomy time, they shall be connected such that failure of an individual battery unit shall not result in the failure of the entire battery system. The battery system shall be connected such that individual battery units are able to be removed/bypassed whilst the remainder of the system is operational.

All batteries and battery cells shall be the same make, model, case type and age, and shall have the same battery specifications (V, Ah, C factor/discharge rate etc.).

Batteries shall have a minimum five year design life and at the time of onsite commissioning shall not be older than six months (from the date of manufacture).

10.7 Bypass

The UPS shall include a proprietary bypass switch such that the UPS can be bypassed with mains power. When the switch is placed in the bypass position, both the UPS input and output shall be disconnected, with the circuits normally supplied by the UPS then connected to mains power.

The UPS bypass switch shall:

- Be hardwired (plug-socket arrangements are not acceptable).
- Include monitoring and SCADA display of the bypass switch position.
- Not switch the neutral conductor.

10.8 Installation and enclosures

All UPS and battery systems are to be installed in accordance with the requirements of *AS/NZS 3000*, *AS/NZS 5139* and *AS/NZS 3011.2*.

10.8.1 Treatment plants

UPSs and battery systems shall be installed within air conditioned switchrooms.

The UPS, bypass switch and any associated backup batteries are to be rack mounted within a common proprietary 19" rack enclosure.

The use of a tower UPS and/or tower battery system is subject to written Principal approval.

10.8.2 Network sites

Where practicable the UPS, bypass switch and any associated backup batteries shall be rack mounted within a proprietary 19" rack enclosure and installed within an air conditioned switchroom or building.

Where a UPS and battery system is required to be installed within an outdoor switchboard/panel it shall:

- Be rated for 50°C.
- Be installed within a dedicated compartment/panel that includes sun shields. Enclosures shall comply with Section 16 Switchboards.
- Include ventilation as required by the ventilation calculations and to ensure reliable operation in accordance with the OEM recommendations. Ventilation inlets are to be fitted with filters to prevent the ingress of dust.

10.9 UPS power distribution

Power distribution from the UPS to supplied equipment shall be via an enclosed circuit breaker distribution board.

The distribution board shall be located adjacent to the supply circuit breaker for the UPS.

10.10 Power supply to the UPS

UPS input power shall be supplied from a non L&P distribution board downstream of the main switchboard via a 6kA miniature circuit breaker.

11 D.C. UPS systems

11.1 Submissions

The following shall be submitted as part of the detailed design report:

- UPS maximum demand including detail of all connected loads and spare capacity requirements.
- Calculations and/or documentation to support the UPS sizing, including any applicable derating to suit the installation environment.
- Calculations and/or documentation to support the UPS battery sizing, and in particular compliance with the required autonomy time.
- Calculations and/or documentation to support the UPS recharge timeframe.

11.2 General

All d.c. UPS systems are to be installed in accordance with the Hunter Water standard design which is available upon request. In accordance with the standard design the d.c. UPS shall supply all ELV circuits associated with the installation excluding the motor starter control circuits.

The installation of d.c. UPS batteries shall comply with the requirements of *AS/NZS 3000* and *AS/NZS 5139*.

The d.c. UPS shall:

- Be sized for the load imposed by all connected equipment plus 30% additional capacity.
- Allow for the inrush current of contactors and relays and the like, as well as providing sufficient overload capacity to ensure operation of downstream protective devices, in the event of a fault on any sub-circuit without going into its fault mode.
- Have a battery fault and buffering contact that is connected to the PLC for monitoring/alarming.
- Have the output 0V directly connected to earth.
- Be installed in accordance with manufacturers recommendations, including the provision of additional forced ventilation where required to preventing overheating.
- include batteries with a minimum design life of 5 years.

11.3 Batteries

Batteries shall be gel, sealed lead/acid recombination type or lithium.

All batteries and battery cells shall be the same make, model, case type and age, and shall have the same battery specifications (V, Ah, C factor/discharge rate etc.).

Batteries shall have a minimum five year design life and at the time of onsite commissioning shall not be older than six months (from the date of manufacture).

Each individual battery is to be clearly labelled with the date of manufacture.

12 D.C. power supplies

12.1 Submissions

For treatment plant sites the following shall be submitted as part of the detailed design report:

- Maximum demand including detail of all connected loads and spare capacity requirements.
- Calculations and/or documentation to support the d.c. power supply sizing, including any applicable derating to suit the installation environment.

12.2 General

24 V d.c. power supplies shall:

- Include N+1 redundancy, and be wired via a dedicated proprietary diode redundancy module to prevent any back feeds to either power supply in the event of an internal fault.
- Be sized for the load imposed by all connected equipment plus 30% additional capacity.
- Allow for the inrush current of contactors and relays and the like, as well as providing sufficient overload capacity to ensure operation of downstream protective devices, in the event of a fault on any sub-circuit without the power supply going into its fault mode.
- Have a fault contact from each unit or the common redundancy module that is connected to the PLC for monitoring/alarming via SCADA.
- Be connected to one set of active and 0V links, with the 0V link directly connected to earth.
- Be installed in accordance with manufacturers recommendations, including the provisional of additional forced ventilation where required to preventing overheating.
- Provide sufficient ventilation to prevent the power supplies from overheating.
- Be mounted to allow for one power supply to be removed while the other (N+1) is still operational.

Not be installed within the PLC cubicle.

12.3 Treatment Plants

At treatment plants all D.C power supplies shall be UPS backed.

Power supplies, circuit breakers, distribution fuses and links shall be installed within a dedicated compartment within the associated switchboard. Alternative distribution fuse locations are subject to Principal approval.

13 Generator and protection system batteries and chargers

13.1 General

Battery and charger systems are designed to operate under nominated ambient conditions. Temperature rise limits shall be based on a maximum ambient temperature of 50°C. Batteries and chargers shall be de-rated as required to ensure compliance.

Battery charger and battery enclosures shall comply with Section 16 Switchboards.

Unless otherwise specified, all batteries and chargers supplied shall be identical and capable of operating in parallel.

Each system shall provide a minimum of 10 hours back-up power at full rated load.

The systems shall be designed to conform to the following specification:

- input voltage rating 230 V a.c. – 10%, 50Hz – 5%
- enclosure rating IP42 (minimum)
- bottom cable entry

13.2 Design

13.2.1 Battery chargers

Battery chargers are to incorporate reliable modern equipment selected to provide a minimum service life of 15 years.

Batteries and chargers shall be housed in a single common cubicle where practical, and the construction of the cubicle shall provide separate compartments for electrical equipment and batteries.

The following facilities shall be provided:

- Voltage input – 230 V a.c., 50Hz single-phase input
- input, battery and load circuit breakers
- power ‘On’ red light
- LCD display for indication of output voltage, charging and discharging current through the battery
- manual boost charge selection switch
- individual alarm relay contacts
- battery test facility

The following protective equipment shall be provided:

- reverse polarity
- diode damage from a.c. voltage spikes
- under-voltage charging
- over-voltage
- short-circuit of output

- earth fault
- automatic current limit of output current
- hazard signage

13.2.2 Battery systems

The systems shall consist of a battery bank and battery charger capable of 125% duty.

The batteries shall be capable of accommodating operating and tripping devices activated simultaneously at least three times in succession, without the final voltage being less than 80% of rated voltage.

The batteries shall have a minimum design life of 5 years.

All battery cells and cases shall be identical.

Bolted solid link connections shall be provided between all cells on the same tier. Two independent cable connections shall be provided between banks of cells on different tiers.

Provide information on the volume of water consumed and hydrogen gas generated during a boost charge cycle. This information shall be used to determine the ventilation requirements for the installation.

Lead connectors to be supplied between tiers to remove the potential of working with low voltages.

High CCA automotive batteries for starting diesel generators shall include monitoring for electrolyte level and temperature rise.

Battery design and installation shall comply with the requirements of *AS/NZS 3000* and *AS/NZS 5139*.

13.3 Installation

All battery banks and charger systems are to be free-standing and where applicable be supported by a plinth, battery banks are not permitted to be directly mounted on computer type flooring. The distribution board is to be wall mounted.

14 Low voltage switchgear

14.1 Circuit breakers

14.1.1 General

All circuit breakers shall:

- Have a fault breaking capacity suitable for the fault rating of the installation. This may include cascading combinations where supported by OEM documentation.
- Have flags or indicators such that the position of the breaker can be visually determined with the door open or closed. These indicators or labels shall have ‘Off’ for the open position and ‘On’ for the closed position, ‘0’ and ‘I’ are not acceptable. Miniature circuit breakers are exempt from this clause.
- Be interlocked with the cubicle door to prevent access whilst the circuit breaker is in any position other than ‘Off’. Circuit breakers must show a tripped condition by the mechanical movement of the operating mechanism to an independent tripped position. Miniature circuit breakers and ACBs are exempt from this clause.
- Have the facility to be padlocked in the ‘Off’ position. This facility is to be available when the cell door is both open and closed.
- Clearly display the manufacturer’s circuit breaker nameplate even when circuit breaker accessories are fitted.

14.1.2 Miniature circuit breakers

Miniature circuit breakers (MCB) shall have a minimum fault breaking capacity of 6kA to *IEC 60947-2* and shall have fault current limiting devices installed upstream where required to limit the fault level.

14.1.3 Moulded case circuit breakers

Moulded case circuit breakers shall:

- Be electronic with adjustable thermal and magnetic pickup.
- Be selected as appropriate for the installation fault level (Icu) and have a service breaking capacity (Ics) of 100%.
- Be mounted on the equipment mounting plate with the handle shaft connecting to the door-mounted handle. The handle shaft is to facilitate ready alignment with handle mechanism.

14.1.4 Air circuit breakers

Air circuit breakers (ACB) shall:

- Have electronic protection incorporated with adjustable instantaneous, thermal, magnetic settings and time delays.
- Be mounted within a segregated cubicle with pad lockable outer door as follows:
    - Kiosk transformer switchboards: draw-out type with padlocking facilities for locking in the open and withdrawn position. The racking handle shall be stowed within the ACB when not in use.
    - All other installations: fixed type with faceplate to protrude through an inner escutcheon.

- Include separate key interlocking and padlocking facilities.
- Include remote operation facility via a remote control panel or HMI.

14.1.5 Residual current circuit breakers

Residual current devices shall be installed on circuits as per *AS/NZS 3000*.

14.2 Fuses

Fuses shall:

- Be suitable for the fault level of the installation and achieve selectivity in accordance with *AS/NZS 3000*.
- Where used as a fault current limiting device, be selected to ensure the let-through energy and peak current cut-off protects the downstream switchgear/equipment.

14.3 Low voltage isolation switches

Isolation switches shall:

- Comply with *AS/NZS IEC 60947.3*.
- Be suitable for fault-making / load-breaking duties.
- Be interlocked with the cubicle door to prevent access whilst the circuit breaker is in any position other than ‘Open / Off’
- Have the facility to be padlocked in the ‘Open’ position. This facility is to be available when the cell door is both open and closed.
- Be mounted on the equipment mounting plate with the handle shaft connecting to the door-mounted handle. The handle shaft shall be installed to facilitate ready alignment with handle mechanism.

14.4 Generator changeover switches

Generator changeover switches shall be clearly marked as to which handle position is ‘Off’, ‘Generator’ and ‘Mains’.

Due to potential risk of arc flash, the switching from mains power to generator power shall be as follows:

- For sites ≤80amp manual changeover (whole current) switches may be used; and
- For sites >80amps mechanically interlocked circuit breakers must be used. The circuit breaker on the mains power side may be non-auto.

14.5 AC contactors

Comply with *AS/NZS IEC 60947.2* and as per Hunter Water Approved Electrical Products List.

Coil voltages shall be 24 V d.c. except for contactors coil consumption above 150W (pickup). These shall be interfaced with a relay to control a 230 V a.c. coil.

14.6 Protection devices on LV motors

All motors shall have overload protection with manual and auto-reset options available. Motors supplied from a VSD or soft starter shall use the in-built protection.

Motor protection shall meet the requirements of the following table:

Installation location/motor rating	**Overload protection requirements**
Network DOL motors 15kW and below	Tripping class of 10 or 10A, auto/manual reset, trip indicator and separate N/O and N/C contacts.
Network DOL motors above 15kW	Electronic overload devices which feature adjustable tripping curves, thermistor input, phase loss, asymmetry protection, power measurement and Ethernet connection to the control system for monitoring. Additional mechanical protection devices e.g. vibration sensors, seal fail devices, over torque sensors etc. shall also be included.
Treatment plant DOL motors	Electronic overload devices which feature adjustable tripping curves, thermistor input, phase loss, asymmetry protection, power measurement and Ethernet connection to the control system for monitoring. Additional mechanical protection devices e.g. vibration sensors, seal fail devices, over torque sensors etc. shall also be included.

14.7 Monitoring

All monitoring circuits shall be supplied via a UPS backed supply.

14.7.1 Air circuit breakers:

Configure and program the local SCADA and HMI and send to Head Office SCADA the following information:

- racked in, racked out status (if rack-able)
- open/closed status
- tripped status

14.7.2 Air break switches and isolator switches

Configure and program the local SCADA and HMI and send to Head Office SCADA the following information:

- Open/closed status

14.7.3 Generator Changeover Switch

Configure and program the local SCADA and HMI and send to Head Office SCADA the following information:

- Changeover Switch Status ‘Mains Supply’ or ‘Generator Supply’

14.7.4 Protection Relays

Configure and program the local SCADA and HMI and send to Head Office SCADA the following information:

- all utilised alarm statuses
- current (RMS per phase, RMS earth value)
- volts (RMS per phase, RMS earth value)
- power (kW, kvar, kVA) if available

15 Electronic drives

15.1 Submissions

The following shall be submitted as part of the detailed design:

- Calculations and/or documentation to support the drive sizing, including any applicable derating to suit the installation environment.
- Details of external venting systems to divert VSD heat external to a building, including dimensioned drawings and any civil/structural modifications.
- Certification/sign-off from a qualified structural engineer where VSDs are to be supported/mounted off the switchroom wall.
- Verified procedure as required for safe removal of drive equipment from the switchboard.

15.2 General

All drives shall have a HMI which is accessible without opening the door of the cell or enclosure housing the drive. The HMI cable shall have sufficiently high insulation rating and EMI immunity to be safely installed with other ELV control cables. Installation of such cables in the same duct or conduit as LV cables is prohibited.

Where pump-controlled stopping is required this shall be carried out using a variable speed drive.

All equipment associated with the drive, e.g. line chokes and EMC filters, shall be mounted in the same enclosure as the drive. Drive equipment weighing more than six kilograms installed within a switchboard shall be mounted on welded studs.

All floor-mounted drives shall be mounted either on a full perimeter, minimum 100mm high x 50mm wide x 6mm, hot dipped galvanised mild steel channel plinth, or suitable proprietary design, subject to Hunter Water's approval.

Electronic drives which have had additional equipment added, such as circuit breakers, contactors and relays, shall be classified as a switchboard and comply with the switchboard section in this STS.

15.3 Ventilation and cooling

15.3.1 General

Cooling shall be provided to keep the temperature of all electronic drives below their de-rated value. Subject to other specific requirements, cooling may consist of a combination of internally vented systems, externally vented systems and/or air conditioning. The design shall cater for an ambient temperature of 40°C in switch rooms and 50°C for outdoor applications and consider the effect of any additional heat sources in the area.

15.3.2 Externally vented systems

Inlet air shall be drawn over the main heat sources and exhausted directly outside via ductwork. If the enclosure includes a transformer or passive filter section, that section shall be ventilated similarly. All equipment in the externally vented sections shall be fully segregated from any general control equipment

which could be affected by dust, corrosive gas or other sources of pollution. In the case of transformers or passive filters, all exposed conductors shall be insulated or suitably shrouded.

Air inlets and outlets shall be fitted with fine mesh screens to prevent entry of insects and/or vermin. Air flow calculations shall consider impact due to mesh screens and filters. Where the pressure drop of the ductwork and filters is greater than the OEM specification for natural ventilation, install a dedicated inline ventilation fan.

Provide ductwork as necessary to exhaust air outside the building. Exhaust ductwork detail arrangement including wall penetrations shall be designed with:

- downward facing or sheltered outlet openings to prevent possible rain ingress
- easy access by operations personnel for routine removal and cleaning

15.4 Variable speed drives

15.4.1 Minimum specification

The VSDs shall incorporate:

- Modbus TCP/IP Ethernet or Ethernet/IP connections
- onboard analogue and digital I/O capable of remote monitoring via communications
- external HMI.

The VSDs shall be selected to achieve:

- Continuous operation at the motor FLC rating
- Minimum of 110% overcurrent of drive continuous current rating (60 seconds) for variable torque loads (centrifugal pumps/fans) and 150% overcurrent of drive continuous current rating (60 seconds) for constant torque loads (PD pumps/fans).

15.4.2 General installation

All VSDs shall be installed as per *IEC 61800-3* in either the first or second environment, depending on the power supply characteristics for the installation location. Installation of VSDs in the first environment shall conform to the requirements of category C2. Installation of VSDs in the second environment shall also conform to the requirements of category C2 where practical. A category C3 installation may be considered in certain situations, and is subject to written approval from Hunter Water.

The controller shall be configured to be ready for operation following a power failure and subsequent restoration without manual intervention.

A separately fused 24 V d.c. UPS backed auxiliary supply shall be used to maintain control power to the VSD when mains power is off.

Each type of fault is to be individually indicated on the HMI. Fault indications should remain active after the controller has been stopped and/or tripped due to the fault condition or the line contactor being opened.

15.4.3 Switch room installations

When installed in a switch room/pump-house, VSDs greater than 1.5 kW shall be installed separately outside of the switchboard and rated to a minimum of IP54.

Small VSDs rated up to 1.5 kW may be installed in the MCC switchboard where sufficient space is available for adequate air circulation around the VSD, to prevent drive overheating. For VSDs installed within a switchboard the VSD HMI shall be installed remotely on the MCC cell door and shall not compromise the IP rating of the switchboard.

VSDs up to 75 kW may be wall mounted or floor standing. Wall mounted VSDs shall meet the following minimum requirements:

- Minimum IP54 rating.
- Mounting via a Unistrut-type mounting system. Care should be taken to ensure the wall can withstand the total weight of the VSDs, along with any additional equipment.
- Fixing to the Unistrut-style frame via a 5mm galvanised mounting plate or equivalent mounting solution to suit the manufacturers installation requirements/recommendations.
- Include cable tray with adequate mechanical cable protection.

VSDs above 75 kW shall be floor-standing only and be minimum IP54 rated.

All wall/floor mounted VSDs shall be bottom connected.

15.4.4 Protection

Protection within the VSD shall trip the controller in the event of a fault and prevent restarting of the controller until manually reset.

All VSDs controlling motors rated 18.5 kW and above shall include motor thermistor inputs as a minimum. Additional RTDs may be utilised on large motors which may also be directly connected to the VSD. The VSD shall be capable of providing alarm and trip functions for these devices.

15.4.5 Line chokes/DC bus chokes

All VSDs shall be fitted with either a line choke or d.c. bus choke to minimise THDi at the drive. Where drives are used in conjunction with AHFs, consult the AHF and drive manufacturer for recommended application of chokes.

15.4.6 Motor chokes

Motor chokes may be required when VSDs are used with long motor cable lengths. Install motor chokes in accordance with the manufacturer's documentation. The choke shall include a thermostat switch that when operated trips the VSD by activating a logic input. This switch shall be displayed on the drive HMI.

15.4.7 Earthing frequency interference

Installation and earthing shall be in accordance with the manufacturer's recommendations and shall take into consideration the following:

- VSDs mounted remotely from a switchboard shall be earthed directly to the main switchboard earth bar, as per the protective earth requirements in *AS/NZS 3000* and *AS/NZS 3008*.

- Where drives are mounted within enclosures they shall be installed on a suitable galvanised and unpainted mounting pan suitably bonded to the main earth of the enclosure, using flat, braided conductors. The enclosure door shall be earthed to the frame of the enclosure using flexible, braided straps. Building wire is unacceptable for this purpose.
- All VSD motor earths shall be connected directly between the motor and the dedicated motor earth terminal on the VSD. Where the motor earth passes through a local control panel or link box the earths continuity shall be maintained via termination on a non-insulated protective earth bar or earthed terminal.
- Unless otherwise specified only braided screened motor cables shall be used for all motors controlled via a VSD, with the exception of submersible pumps where a combined motor earth and screen is acceptable.
- The screen shall be continuous between the motor and the VSD and shall be connected as follows:
    - At the VSD the screen shall be earthed in accordance with the OEM guidelines. Note for VSDs installed within a switchboard/enclosure an EMC gland shall not be used where the braided cable passes through the enclosure gland plate unless this is specifically required by the OEM guidelines.
    - At local control panels or link boxes where the cable includes a separate motor earth and screen the cable screen shall be terminated using proprietary EMC glands.
    - At local control panels or link boxes where the cable includes a combined motor earth and screen (e.g. submersible pumps) a standard gland shall be used and the common earth/screen shall be connected to the non-insulated protective earth bar. In addition, the gland plate shall be earthed to the enclosure and the protective earth bar, via individual flat, braided conductors.
    - At the motor terminal box, the screen shall be terminated using proprietary EMC glands.

Special attention is drawn to the correct application of EMC cable glands. Glands that have loose components such as springs or chains shall not be used (see Hunter Water approved electrical products and manufacturers list for guidance).

15.4.8 VSD communications

Provide a Modbus TCP/IP Ethernet or Ethernet/IP connection between the VSD and the control system PLC for control and monitoring.

Backup control shall be via a hardwired interface so when switched to ‘Test’ the VSD will run with its speed reference coming from either its on-board HMI or pre-programmed reference.

Connection to the control system shall be via minimum Cat 5e SF/UTP patch leads with RJ45 metallised connectors. Leads shall be proprietary factory-made and green in colour.

15.5 Soft starters

All soft starters are to be configured to run in bypass once the motor is up to speed.

Soft starters shall be rated for continuous operation without bypass for the full load current of the motor and capable of a minimum of 12 starts per hour at 50°C ambient temperature.

Soft starters with integral bypass are permitted, provided they meet the above temperature and number of start requirements.

16 Switchboards

16.1 Design

Switchboards and MCCs shall be designed and have verification of performance when subjected to the following tests as per *AS/NZS 61439*, unless otherwise specified:

Construction Requirements –

- Strength of Materials and Parts
- Degree of Protection of Enclosures
- Clearances and Creepage Distances
- Protection Against Electric Shock and Integrity of Protective Circuits
- Incorporation of Switching Devices and Components
- Internal Electrical Circuits and Connections

Performance Requirements –

- Dielectric Properties
- Temperature Rise Limits
- Short-Circuit Protection and Short-Circuit Withstand Strength
- Electromagnetic Compatibility (EMC)
- Mechanical Operation

In general, these verification tests will be in line with *Annex D* of *AS/NZS 61439.1* and shall meet minimum verification requirements of *AS/NZS 61439.1*.

16.1.1 General

Switchboards shall be designed and manufactured so they may be readily moved to, and installed in, the required locations. Indoor switchboards shall be able to be installed inside a completed building/switch room using readily available lifting and handling equipment and without the need to remove doors, walls or roofs.

Ambient conditions for equipment selection shall be assumed to be within the following limits:

- -10°C to 50°C for all outdoor and non-air-conditioned indoor installations
- 10°C to 40°C in an air-conditioned switch room

Nominal system parameters: 400V three-phase, four-wire, 50 Hz, multiple earthed neutral (MEN) system. MEN link shall be readily accessible, as required by *Service and Installation Rules of New South Wales*.

Package plant with a manufacturer's proprietary switchboard shall be acceptable only if they conform to this STS, in particular colour coding of cables.

All control circuits, inputs, outputs, and instrumentation shall have a 24 V d.c. supply.

All LV wiring within an enclosure shall be able to be isolated from one point of supply.

Motor protection shall only be installed in dedicated switchboards and not in local or field panels.

Equipment requiring regular access or that includes a display or indication lights for diagnosis shall be installed between 300 and 1800mm of the finished floor level.

Switchboards shall be designed and installed to achieve *AS/NZS 3000* clearance requirements.

Main switchboards and MCCs shall be designed in accordance with the following:

- modular cubicle-type construction (indoor) / custom construction (outdoor)
- degree of segregation: Form 4a
- degree of protection: IP42 minimum (indoor) / IP56 minimum (outdoor)
- free-standing and self-supporting
- front access only with bottom cable entry
- adequately ventilated, dustproof, and vermin and insect-proof
- use four-pole bus droppers
- each tier shall have one cable zone of minimum 360mm width.

The main switch on all main switchboards and MCCs shall be a circuit breaker, incorporating electronic protection with adjustable thermal, magnetic pickup and time-delay settings. This circuit breaker shall be set to provide selectivity (discriminate) with the upstream protective device.

The design shall include 20% of spare cell space based on total used cubicle footprint to allow for future expansions.

Floor-mounted and free-standing steel switchboards shall be mounted on a full perimeter minimum 100mm high x 50mm wide x 6mm thick mild steel channel plinth. The plinth shall be hot dipped galvanised after fabrication to a minimum thickness of 85 micrometres and shall not be painted.

16.1.2 Arc flash mitigation

All main switchboards and MCC's shall be manufactured to achieve increased security against the occurrence or effects of internal arcing faults in accordance with *AS/NZS 61349.1 Appendix ZC*.

Verification documentation in accordance with *AS/NZS 61439.1 Appendix ZD* is to be submitted in accordance with Section 6.6.

Exemption for custom switchboards is subject to Principal approval.

Note: Custom outdoor water and wastewater pump station switchboards constructed in accordance with the standard Hunter Water design are not required to comply with this clause and do not require exemption approval from the Principal.

16.1.3 Intelligent motor control centres

Treatment plant MCCs shall be intelligent motor control centres (IMCC). IMCCs shall include the following:

- an Ethernet-based (Modbus TCP/IP) communications network between the PLC, Ethernet switches and all motor starters, as per *STS 550 – General Requirements for SCADA and Automation Systems*.
- intelligent motor starters that are either DOL or VSD – DOL starters are to incorporate an Ethernet motor protection relay and VSDs are to be fitted with Ethernet facility. The ELV supplies to these Ethernet connected devices are to be from the site UPS supply similar to all other control network devices.

- motor protection relays and VSDs are to be implemented without using custom logic in the device – all logic is to be done within the PLC code.
- VSDs shall have a similar input/output configuration as the motor protection relay and be controlled/monitored via communications.
- the only devices that may be installed on the MCC cell door are the ‘ VSD HMI and the main circuit breaker handle. The ‘Test – Off – Auto’ switch and start/stop pushbuttons shall be installed on the local control panel.
- drive status, motor running and motor currents are to be displayed on the switchroom HMI which is to be installed on the PLC cabinet door. Note only a single HMI is required per switchroom.
- each drive is to have its own page on the HMI which also displays, as a minimum, faults and process variables.
- all starters are to be able to be controlled from the field start/stop pushbuttons when selected to ‘Test’.

16.1.4 Indoor switchboards

16.1.4.1 Classification

Indoor switchboards are defined as those that are located in a designated electrical switchroom or a building that does not have a wet or corrosive environment or a damp atmosphere.

Examples of indoor switchboards are:

- MCC’s, distribution boards, PLC/communication panels etc. installed internal to a building (no wet environment).
- MCC’s, distribution boards, PLC/communication panels etc. installed within a dedicated switchroom.

16.1.5 Outdoor switchboards

16.1.5.1 Classification

Outdoor switchboards shall be used if they are to be installed externally to a building or within a wet or corrosive environment or damp atmosphere. Note any building that contains pipework under pressure is considered to be a wet environment.

Examples of outdoor switchboards are:

- Wastewater pump station switchboards installed external to a building.
- Switchboards located in any building/room that contains pipework under pressure (i.e. wet environment).
- Local control panels installed external to a building.
- Remote I/O panels installed external to a building.

16.1.5.2 General

Vent systems shall prevent the ingress of vermin and/or insects by the use of Termimesh, or similar.

The switchboard roof shall be sloped or contain a crease design to ensure water shed and avoid pooling.

A 24 V d.c. IP54 LED light strip shall be included:

- Within each cubicle between the inner and outer doors in pumping station switchboards.
- In all cubicles that contain automation and telemetry equipment.

All the light strips shall be supplied from the PLC cubicle 24 V d.c. power supply and be operated from the switchboard door's limit switches.

16.1.5.3 Heat shields

All switchboards with automation and telemetry equipment and/or heat generating equipment shall have a stand off heat shield with an air gap of 25mm on all exposed surfaces, including doors. The heat shield is to cover the surface area of the switchboard without protruding past the sides of the switchboard doors, have smooth and returned edges and shall provide ample clearance for the door handle to be operated without injury to personnel. The installation of heat shields shall not compromise the IP rating of the board and earth continuity must be maintained.

Heat shields are not required on the following:

- switchboards installed indoors (e.g. pump-house).
- local control panels.
- field instrument panels.
- generator changeover panels.
- proprietary distribution boards.

Examples of switchboards requiring heat shields include:

- all outdoor pump station switchboards.
- remote I/O panels installed external to a building.
- switchboards housing electronic starters, automation and telemetry equipment, or heat generating equipment.

16.1.6 PLC I/O cubicles

When a PLC I/O cubicle is integrated within a switchboard or MCC the cubicle shall be to the same height as the remainder of the switchboard, and include a full-height steel barrier between the PLC tier and any adjacent tiers housing power distribution or motor starter equipment.

16.1.7 General light and power distribution boards

Distribution boards shall:

- not be part of a switchboard or MCC.
- be proprietary, enclosed, and with single or three-phase insulated busbars.
- be fitted with a main switch which is able to be padlocked in the off position.

Low voltage GPO's and lighting shall be protected from an RCD-MCB unit at the power & lighting sub-board.

Light and power distribution boards shall have the circuit breaker clearly numbered and the legend shall reference these numbers. For multi-pole circuit breakers, the circuit breaker number shall be the first

active pole. Provide a neatly printed and laminated legend, Arial, font size 11, inside the door detailing each circuit designation and circuit breaker rating, handwritten being unacceptable.

16.1.8 Fault levels and time of duration

All switchboards shall be designed and constructed to meet or exceed the maximum fault level for the area of installation as defined by the NSW SIR.

16.1.9 Fault current limiting

Circuit breaker cascading shall be used where fault current limitation is required. Equipment selection shall be as per manufacturer's data.

Fault current limiting fuses shall only be used with approval from Hunter Water.

16.1.10 Power monitoring

Provide a power monitor on each switchboard . The power monitor shall have a remote display mounted on the door with a communication cable to the base unit. Alternatively a suitable circuit breaker with equivalent power monitoring data may be used.

Provide additional power monitoring for each individual load expected to consume at least 35MWh per year. Power monitoring on individual loads may utilise either a dedicated power meter or power monitoring incorporated into a protection device dedicated to that load. The power monitor shall communicate the required parameters to the PLC and SCADA system via Ethernet TCP/IP. These individual loads only require instantaneous power and instantaneous current to be monitored via SCADA. There is no requirement to display the information local to the switchboard.

16.1.11 Motor starter requirements

All new switchboards shall use 24 V d.c. internal control circuit for starters.

The motor starter cubicles shall be demountable or fixed modular type with items of equipment, arranged to fit within the modules. Withdrawable motor starter cubicles are unacceptable. All components associated with a particular motor or item of equipment shall be grouped together in an individual motor control module.

Motor starting current shall not exceed the limits nominated within the NSW SIR's.

Modules shall be a minimum size of 200mm high x 560mm wide.

Demountable cubicles shall incorporate an early make late break earth connection.

Each module shall be self-contained with its isolator mechanically interlocked with the module's door. Module isolation door handles shall be located as close as possible to the module's door lock mechanism.

The isolator position shall be monitored in SCADA.

Select motor starter equipment for type 2 short circuit coordination as per manufacturer's recommendations on all treatment plants, and those pumping stations which are greater than 400 amps.

16.1.12 DC distribution board

The distribution board shall include a main switch, standard busbar chassis and d.c. rated distribution MCB's.

16.1.13 Local control panels

Supply and install a separate individual local control panel adjacent to each individual motor at treatment plants, or where required. Locate local control panels so they are readily accessible and identifiable.

Local control panels shall include:

- full current isolator fixed on the enclosure mounting plate and mechanically interlocked with the door to prevent door opening while in the 'On' position. Isolator shall include an early break late make contact in starter control circuit and position monitoring via SCADA
- test start pushbutton
- test stop pushbutton
- 'Test – Off – Auto' switch
- reverse pushbutton for motors with reversing starters
- emergency stop relays and pushbuttons where required
- Factory fitted gland plates.

All motor starter protection and control equipment not specifically listed above shall be mounted within a dedicated starter cubicle in the switchboard or MCC.

Local control panels mounted external to a building shall include:

- a pad lockable hinged outer door that prevents access to any isolation or control equipment.
- isolation or control equipment mounted on an internal hinged door/escutcheon.
- a fixed section on the front of the panel below the outer access door for mounting of the emergency stop where required.

Perspex windows shall not be installed on local control panels.

16.1.14 Circuit breaker remote control panels

The following functionality shall be included within hardwired remote control panels:

- Hardwired selector switches for each circuit breaker being remotely operated.
- Hardwired selector switches for each isolator switch (where remote operation for isolators is required) being remotely operated.
- The selector switch shall be three-position, spring return to centre. The selector positions shall be 'Open/Off/Closed'.
- The wiring shall interconnect with the circuit breaker's local controls.
- Hardwired indication lamps for the following statuses – 'Open', 'Closed' and 'Tripped'.
- The selector switch and indication for each switch shall be grouped together and arranged on a SLD printed on traffolyte, or similar, on the front panel.

- Where installed external to a building all controls are to be installed on a hinged inner escutcheon located behind a pad lockable external outer door.

The following functionality shall be included within HMI remote control panels:

- 15” touch screen HMI.
- ‘Open/Close’ functionality for all circuit breakers and isolators being controlled.
- Opened, Closed and Tripped status of all circuit breakers and isolators being controlled.
- HMI screens developed to mimic the single line diagram.
- A permissive key/lock facility on the outer door that enables/disables HMI control.
- Where installed external to a building the HMI and permissive key/lock facility is to be installed on a hinged inner escutcheon located behind a pad lockable external outer door.

16.1.15 Generator connection panels

16.1.15.1 General

All main switchboards shall include a generator changeover switch and associated generator connection point that can be safely accessed when the switchboard is live.

Refer to Section 14.4 for the generator changeover switch requirements.

Generator changeover switches and connection panels shall be sized to suit the site maximum demand (refer Section **Error! Reference source not found.**).

The generator connection panel design shall consider the maximum generator cable size that may be required to be connected at the site. Confirmation of the maximum generator cable size to be connected is to be sought from Hunter Water and as a minimum shall include:

- Direct metered supplies – 70mm2 flexible single core
- All other switchboards – 240mm2 flexible single core, or multiples thereof.

When designing a new generator connection point, generator laydown areas must be identified on the area drawings and loading and unloading space provided for the appropriately sided generator.

Generator sizing shall also be stipulated on SLD.

Generator connection panels shall include the following minimum requirements:

- Phase colour identified hard-drawn, high-conductivity tinned copper link bar installed on proprietary standoff insulators. Link bar is to be pre-drilled and include fixing bolts, nuts and compression washers to suit. Note where space constraints prevent the use of link bar proprietary terminals may be used following Principal approval.
- Pad lockable outer door which is capable of being locked when the generator cables are connected.
- Hinged pad lockable access cover to allow bottom entry of generator cables. The access cover shall be designed so that in the closed position the fitting of the padlock solely ensures the required IP rating of the enclosure is maintained i.e. additional fixings shall not be required in addition to the padlock.
- Internal sliding cover that is able to be fixed in position against the generator cables in order to prevent access to the live terminations/busbar whilst the generator is connected.

- Suitable clearance between the cable access hatch and the link bars to facilitate routing/connection of the generator cables.
- Cable attachment point/bracket to ensure that no mechanical stress is placed on the connections.

16.1.15.2 Installation location

Generator connection panels shall be integral to the switchboard for all external main switchboard installations. Where the main switchboard is installed within a building the generator connection panel shall be a free standing panel installed on the external face of the building in close proximity to the generator laydown area.

The design of an alternative generator connection panel location is subject to Principal approval.

16.2 Construction

16.2.1 General

Switchboards shall only use stainless steel metric fixings. All equipment mounted on mounting plates shall be drilled and tapped using parallel threads. Screws, nuts and washers shall only be used where nuts are easily accessible after assembly. Self-tapping or self-drilling screws shall not be used.

All current-carrying connections shall be with conical washers. Bolt length is to be selected so that approximately two (2) threads protrude through nuts on final installation.

Position all equipment inside switchboards to provide safe and easy access for operation and maintenance. Provide a minimum of 40mm space between all equipment and wiring ducts/cable looms to facilitate wiring connections.

There shall be no LV terminations in cable zones. Motor power cables shall be directly connected to the last device in the power circuit.

16.2.2 Busbars

Horizontal and/or vertical busbar zones shall be enclosed in separate modules completely isolated from each other by means of metal or insulated barriers. In addition to other segregation requirements, where a switchboard has two incoming power supplies, the busbar sections for each supply are to be fully segregated from each other.

Pre-drilled holes at each end of busbars (including earth bars) shall be provided to allow for future extension of the switchboards.

Pre-drilled holes and fasteners for terminating screens shall be provided for all incoming power cables.

The busbars shall be marked with colour coding inside each access point.

Arrange vertical busbars to ensure that the phase sequence at all switchboard equipment terminals is red, white and blue from left to right when viewed from the front of the switchboard.

Busbars shall be manufactured from hard-drawn, high-conductivity tinned copper.

Full radius or radius corner busbars shall be used.

Fit busbar flags to all equipment having main terminals inadequate for the cable size. The size of the flags shall be appropriate for the cable lugs to be terminated and shall have a current rating of not less than the maximum for the frame size of the equipment. Busbar flags shall be supported to ensure that no mechanical stress is placed on connections and maintain creepage and clearance distances.

16.2.3 Indoor switchboards

16.2.3.1 Indoor switchboards finish

Indoor switchboards shall be powder coated. Undertake all surface preparation, powder coating and protective coating in a workshop or factory environment prior to shipping to site.

The preparation and pre-treatment of surfaces shall comply with the *AS 1627* series of standards or equivalent standards.

Powder coating must be applied strictly in accordance with manufacturer's instructions.

All surfaces shall be buffed to give a uniform overall appearance.

16.2.3.2 Powder coating

Powder coating of switchboards shall comply with the following:

- Protect all surfaces from weather conditions after fabrication and complete powder coatings within five days of fabrication. Ensure oxide layer does not form prior to applying coatings.
- Clean off all heat affected areas.
- Use only lead-free materials and powders.
- Coatings shall use premium grade polyester powder designed for use over galvanised or zinc substrates.
- Film thickness shall be 60 to 80 microns or 100 microns where translucence is a problem, e.g. orange pigments.
- Apply and cure powder coatings in accordance with the relevant manufacturer's recommendations.
- Thoroughly remove any non-conforming coatings and reapply until a complying coating is achieved.
- Protect all coated surfaces during storage, transport and installation.

16.2.3.3 Main switchboards and motor control centre requirements

Main switchboards and MCCs shall be:

- Folded sheet metal modules secured together to form a neat, flush composite assembly. Switchboards constructed from bolt together frames are unacceptable.
- Manufacture cabinets, covers, and doors from zinc-annealed steel sheets with a minimum thickness of 2mm.
- All doors on the face of the switchboards shall be held closed using turnbuckle locks with 7mm square pins.

- All tiers containing bus bar shall be fitted with a full height neutral bar. Proprietary 4-pole bus plug shall be used to provide connection to the respective cell.
- All LV connections including neutrals shall be contained within the cell. Run neutral cables on the same route as the phase cables.
- Fully shroud all connections on busbars.

16.2.4 Outdoor switchboards

16.2.4.1 General

Manufacture all switchboard metalwork (including inner doors and escutcheons) in accordance with the following:

- Pumping stations switchboards, pumping station connection boxes, and remote I/O panels: 2.5mm aluminium grade C5251-H34
- Belmont WWTW and Desalination Plant switchboards: 2.5mm aluminium grade C5251-H34
- All other switchboards: 2.5mm aluminium grade C5251-H34 or 2mm grade 316 stainless steel.

Free-standing switchboards shall be mounted on a galvanised steel plinth. Note the use of an aluminium plinth is subject to Hunter Water approval and requires sign-off by a qualified structural engineer.

The stand shall be designed with no sharp edges or trip hazards and shall be robust and rigid.

The enclosure shall be separated from its support stand by appropriate corrosion barriers. Switchboards shall be mounted on dedicated support brackets and not attached to hand or guard rails.

All fixings shall be stainless steel.

Outer doors shall be fitted with 316 stainless steel pad lockable swing handles whilst internal doors shall be fitted with night latch and electrical barrels where there is no mechanical interlock.

Vent systems shall prevent the ingress of vermin and/or insects by the use of Termimesh, or similar.

Install in the PLC cubicle a metal pocket for the storage of A3 drawings within a binder and a proprietary fold-down support base on the inside of the door to facilitate the use of a 15” laptop computer. Where no PLC cabinet is present install the drawing pocket in an alternate cell.

16.2.4.2 Wastewater pumping station cable connection boxes

Cable connection boxes shall be provided between wet wells and the switchboard.

Connection boxes shall be:

- Designed and manufactured in accordance with the Hunter Water standard design.
- Suitable for the particular application and motor rating.
- Mounted on a minimum 500mm-high stand with mesh. At least one side of the mesh shall be readily removable to facilitate replacement of field wiring. Connection box stands shall be arranged with natural ventilation to allow sewer gas to vent to atmosphere.
- Vandal-resistant.

Connection boxes shall have approved proprietary IP2x bolt/stud type terminals including hinged terminal shrouds. Tunnel-type terminals are unacceptable.

16.2.4.3 Junction boxes in outdoor locations

Junction boxes shall comply with the switchboard accessibility requirements of *AS/NZS 3000*.

16.2.5 PLC cubicles

Control equipment (24 V d.c./a.c.) and power equipment (230 V a.c.), including wiring, shall as far as practicable be segregated.

Fully shroud all 230 V a.c. equipment and terminals. LV distribution boards shall be installed in a separate cubicle.

Provide equipment clearances in accordance with the manufacturer's recommendations, with a minimum 25 mm clearance between different adjacent equipment types.

16.2.6 Finish colours

Switchboard colours shall comply with *AS 2700* and be:

- low voltage indoor switchboards: X15 light orange or RAL2000
- internal/removable equipment panels: VSD mounting pans) gloss white or RAL9010 or similar (excludes
- outdoor switchboards natural finish

16.2.7 Equipment mounting pans

Internal mounting pans shall be 2.5mm mild steel powder coated gloss white and shall be suitably braced to form a rigid mounting surface. All mounting holes shall be drilled and tapped.

There shall be no new penetrations or replacement bolts used to retrofit new equipment into an in-service switchboard mounting pan.

Demountable modules shall be a minimum of 2mm thick painted mild steel.

16.2.8 Gland plates

Gland plates are required to provide access to both sides of the cable glands and to provide a means to facilitate pulling cables into cubicles.

The switchboards shall include full-width removable gland plates for each tier or module, (several removable sections may be used), mounted on the base of the switchboard. Gland plates shall comprise 5mm thickness aluminium plate, be fixed with minimum M6 hexagon setscrews, and a preformed gasket to maintain the IP rating of the switchboard.

16.2.9 Doors and covers

16.2.9.1 General

Doors and covers shall be manufactured with right-angle welded corners of sufficient rigidity to prevent warping and flexing when fitted to, or removed from, the cabinet.

All external and inner doors shall have a minimum swing of 90 degrees. At network sites the PLC cabinet door shall be located on the end of the panel and have a minimum external door swing of 135 degrees to allow the PLC fold down table to be used whilst working within the panel..

Incorporate locating and support brackets or studs for any unhinged removable covers, to facilitate easy removal and replacement of the cover.

All doors on outdoor switchboards shall be fitted with a permanent rigid retaining device to prevent inadvertent closing.

16.2.9.2 Sealing

Covers and doors shall seal to the nominated IP rating. The seal shall be continuous to allow all edges of the door to be completely sealed when closed and continuous over hinges. Foam rubber is unacceptable.

Door seals shall be secured in place to prevent them sliding off and being damaged when the door is being closed.

All jointed metal work shall rely on dedicated seals, such as gaskets.

16.2.9.3 Equipment mounting on doors

Equipment mounted on the external surfaces of the switchboard shall be installed so the equipment does not degrade the IP rating of the switchboard. Meters shall be shrouded to achieve the required IP rating.

Equipment mounted on doors shall be arranged so as not to foul when the door or panel is swung fully open.

Arrangement of equipment on doors shall be consistent across the entire switchboard.

Only extra low voltage equipment shall be mounted on doors.

16.2.9.4 Locks and hinges

All electrical equipment shall be behind a Hunter Water electrical lock, except:

- MCC cubicles containing electrical equipment that meet all of the following:
    - a mechanical interlock on the cell main switch
    - the line and load side terminals of cell main switches are fully shrouded
    - the main switch isolates all load side LV power within the cubicle
    - a tool is required to access
- cable zones

Indoor switchboards doors shall be fitted with chrome-plated hinges and handles.

All outer doors exceeding 1.2m in height shall be fitted with three hinges and three-point locks. Locking rods may be used on doors which have no live electrical equipment directly behind the door. Where there is live electrical equipment directly behind the door, three-point locking shall be accomplished with three separate locks, one of which shall house the electrical lock and the others shall be T-handle type.

Doors which enclose service protection device, supply authority meters shall be fitted with a Hunter Water electrical lock or a supply authority lock.

Cubicles are to incorporate a mechanical interlock on the main switch operating handle so the door cannot be opened unless the switch is in the 'Off' position.

16.2.10 Shrouding

All live parts within the switchboard shall provide protection of at least IP2X, including the neutral where it is defined as live in accordance with *AS/NZS 3000*.

All equipment shall be fitted with proprietary terminal shields which incorporate inter-pole barriers to prevent arcing between phases.

Where additional barriers are required to meet the IP rating above, they shall be clear, rigid sheeting protecting small compartmentalised sections of the switchboard. These barriers shall be secured by permanent rigid brackets which allow easy removal and replacement.

Shrouding shall be designed to ensure access to equipment control/buttons is not inhibited.

Shrouding on live parts shall not inhibit access to equipment which may be required to be operated for maintenance purposes, e.g. busbar shrouds shall not block access to fuses.

All connections on the line side of a protective device in each incoming and outgoing functional unit shall be fully shrouded or insulated so as to prevent the possibility of a line side fault developing and to provide personnel protection.

16.2.11 Motor starter requirements

All door-mounted starter components shall be oriented in a consistent arrangement, i.e. push buttons, lamps, ammeters, and so on shall have the same orientation throughout the installation.

Provide individual control terminal strips in the cable zone for each incoming or outgoing control cable adjacent to each module.

Where power cables are connected to equipment, provide sufficient space for easy termination and equipment removal. Items of equipment are not to be mounted in front of other items of equipment. Arrange all equipment within a module to be fully accessible for inspection and maintenance without the removal of other components. Clearance around equipment shall be in accordance with manufacturers' recommendations and allow sufficient clearance for easy removal of the equipment.

Arrange and segregate each final sub circuit such that after switching off the circuit breaker or isolation switch for that circuit all associated equipment (e.g. contactors, indicator lights, meters, control equipment etc.) may be worked upon safely without isolating supply from any source other than ELV. The above shall also apply to terminating or replacing cables.

16.2.12 Field instrument panels

Field-mounted instrumentation panels shall be located adjacent to their respective primary element or sensor.

Each field instrument panel shall include:

- A means to isolate the power supply.
- Surge protection in accordance with Section 8.2.

- Padlockable outer door.
- Terminals for all incoming and outgoing cable cores including spares.
- Proprietary IP66 digital display of analogue value (e.g. flowmeter transmitter, pH transmitter, level display etc.) mounted adjacent to the instrument panel. The display is to be visible in bright sunlight and include a metal flap with a top hinge to prevent direct UV exposure.
- Earth bar
- Dedicated earth electrode connected to the earth bar via minimum 6mm2 cable.
- Factory-fitted gland plates.

16.3 Labelling

16.3.1.1 General requirements

For general design requirements refer to Section 6.12.

Every item of electrical equipment within the installation shall be clearly and accurately labelled.

Switchboard labelling shall comply with AS/NZS 61439 and any additional requirements outlined within this specification.

Labels shall not include No. or #, e.g. Newcastle 9 WWPS, instead of Newcastle No.9 WWPS.

Labels inside switchboards/MCCs or within buildings shall be engraved laminated plastic or photo anodised rigid aluminium. Labels in outdoor locations shall be engraved aluminium. All labels shall comply with the following requirements:

- except where otherwise required, be fixed adjacent to, but not on any item of equipment
- engraved lettering to be black on a white background for laminated plastic
- main switches labels to be red lettering on a white background
- warning and caution labels to be white lettering on a red background
- the minimum height of lettering to be 5mm and of sufficient definition to allow easy reading

Socket outlet labels should state point of isolation including distribution board and circuit breaker numbers.

Labels are to comply with *AS 1319*.

16.3.1.2 Fixing of labels

Labels shall be securely fixed by minimum two screws. Screw holes shall be tapped into the switchboard.

Aluminium rivets be used to fix aluminium labels only.

Self-tapping screws, thread-cutting screws or other screw fixings are unacceptable.

The equipment shall be positively identified prior to fixing labels to ensure the label refers to the correct piece of equipment.

16.3.1.3 Labels

In addition to the switchboard label requirements detailed within *AS/NZS 61439* provide a switchboard label which states the switchboard number, switchboard description, source of electrical supply and incoming cable size. Main switchboard labels shall be a minimum of 100 x 250mm, these labels shall have a minimum of four lines of text, as shown below.

Description	Text size
SWB NUMBER	15mm = 42 Point
SWB DESCRIPTION	10mm = 28 Point
SWB SUPPLIED FROM	8mm = 22 Point
INCOMING CABLE SIZE	8mm = 22 Point

Motor starter labels shall be a minimum of 75 x 150mm, these labels shall have minimum of two lines of text, as shown below.

Description	Text size
DRIVE NUMBER	10mm = 28 Point
EQUIPMENT DESCRIPTION	8mm = 22 Point

Separate sections of enclosures shall be labelled to describe the function of the enclosure, e.g. ‘CABLE ZONE’.

The label for any section or enclosure containing supply authority equipment shall comply with the requirements of the supply authority.

Submit a full label list including lettering size, label size, colours and lettering, one week prior to manufacture.

For identification of final sub circuits in a distribution board, a neatly typed schedule shall be provided. A plastic sheet or laminating shall be used to protect the schedule fixed in a suitable frame mounted on the internal side of the switchboard door.

16.3.1.4 Assembly nameplates

Floor-mounted and freestanding switchboards shall be labelled with essential markings as per *AS/NZS 61439* and *AS/NZS 3000*, as well as the following:

- IP rating
- busbar current rating
- designed fault rating including time
- form factor
- manufactured date

16.3.1.5 Assembly equipment labels

Labels identifying equipment within a switchboard shall be located so the item referred to is obvious and the lettering is not obscured by any equipment or wiring.

The MEN link shall be labelled ‘MEN Link’ on the link and on the outside of internal switchboards.

Labels for fuses shall indicate the rating of the fuse links fitted, for example, ‘Fault Current Limiters 160A’.

Labels for circuit breakers having adjustable protection settings shall indicate the circuit breaker ID and the setting/rating, e.g. ‘SPD 140/160A’.

16.3.1.6 Warning labels

Install warning labels as required by Australian Standards or supply authority rules.

16.3.1.7 Hazard markings

Where the removal of any barrier or shrouding could lead to the possibility of direct contact with live low voltage equipment or terminations, a label with appropriate wording shall be provided for each functional unit. An example of a suitable label is:

Description	Text size
DANGER	10mm = 28 Point
ISOLATE ELSEWHERE BEFORE REMOVING COVER	6mm = 18 Point

Additional hazard labels shall be provided on all doors, covers and escutcheon plates or similar containing electrical equipment.

Examples of suitable labels:

Description	Text size

DANGER AUTHORISED ACCESS ONLY	10mm = 28 Point 6mm = 18 Point

And

Description	Text size
DANGER 400V	10mm = 28 Point 6mm = 18 Point

These labels shall be positioned to be readily seen on the covers of functional units.

Outer doors on external switchboards are not required to include a standalone hazard label as detailed above. The outer door of all external switchboards shall include a yellow electric shock symbol integrated into the aluminium description label.

16.4 Cable/wiring systems

16.4.1 General

Do not use cables to link adjacent circuit breakers where a proprietary busbar assembly can be used for this purpose.

Internal cabling shall be at least V75-insulated with stranded tinned copper conductors.

Control wiring shall be of a size not less than 0.5mm^2 multi-stranded flexible tinned PVC insulated.

Keep cables clear of busbars and metal edges.

All cables shall be enclosed in a duct. Ducts shall be fixed using screws or pop rivets, i.e. do not use self-tapping screws or thread-cutting screws. Ducts shall be of a slotted-type sized for the existing installation, with an allowance of additional 20% spare capacity.

All wiring shall be lugged at each termination. Only use crimp-style lugs sized in accordance with manufacturers' recommendations. Lugs shall be crimped with the correct tooling.

Do not loop earth or neutral cables. Terminate all earth cables at an earth link or earth bar and ensure continuity.

Arrange power cables to ensure that the phase sequence at all switchboard equipment terminals is red, white and blue from left to right, back to front and from top to bottom, when viewed from the front.

Each cable core, including earths, shall be identified with the wire number at both ends using a neat and clear sleeve-type printed identification ferrule, with a minimum lettering size of 3mm. Ferrules shall be

easily read from left to right, bottom to top, and shall be visible without removing any duct lids. Handwritten or dot matrix wire numbers are unacceptable.

16.4.2 Wiring identification colours

Primary insulation shall be coloured in accordance with the following:

- phase wiring (A, B and C) – red, white and blue
- voltmeter and current transformer connections – red, white, blue, black
- 230 V a.c. control active (controlled by isolator in the cell or compartment) – white
- 230 V a.c. neutral – black
- ELV d.c. positive – brown
- ELV d.c. negative – grey
- protective earth – green/yellow
- functional earth – purple

For cables above 35mm^2, and for all double insulated cables, phase identification shall be 25mm-wide heat-shrink bands of the colours tabulated above, applied at each end.

16.5 Earthing of switchboards

All switchboards shall include including earthing in compliance with *AS/NZS 61439*. In addition to any requirements detailed within *AS/NZS 61439* the following earthing shall be installed:

- Earth bars shall run full length of the switchboard and shall be extended the full length of all cable zones.
- Doors (including cable zone doors) and hinged escutcheons shall include a 6mm2 earth strap. Hinges shall not be used to provide continuity.
- Gland plates shall include a 6mm2 earth wire connected from a 6mm stud on the gland plate to the earth bar.
- Switchboard frames shall include a 120mm2 earth connection between the frame and the switchboard.
- Demountable modules shall be fitted with an earth finger which connects to the earth bar.

16.6 Modification of switchboards

When existing switchboard cubicles are being modified or upgraded, all exposed terminals shall be made IP2x.

If a cell or compartment is found to have exposed busbars behind the access door or external panel, shielding or signage shall be installed. Signage shall warn of live exposed busbars behind panel and to isolate elsewhere prior to access.

There shall be no new penetrations or replacement bolts used to retrofit new equipment into an in-service switchboard mounting pan.

16.7 Installation

16.7.1 General

After delivery, the switchboard shall have a full site inspection to ensure that the switchboard has not been damaged during transit.

Refer to *STS 600 – General Mechanical Requirements* for metal fabrication works.

Where a switchboard has been split for installation, it shall be reassembled on-site using materials supplied by the manufacturer. Particular attention shall be given to busbar joints, which shall be tightened to the manufacturer's recommended torque and marked as tightened when complete.

If a switchboard is stored or installed in any area where building work is incomplete, it shall be adequately protected against moisture, corrosion, paint, dust, and mechanical damage.

16.7.2 Switchboard support

All freestanding switchboards are to be fixed to a permanent floor either directly via the plinth, or indirectly via a heavy-duty stand. Fixing must be via chemically anchored bolts. Chemically anchored bolts must comply with *STS 600 Section 6.2 Anchor bolts (non equipment)* and the manufacturers installation guidelines.

Fixings are to be positioned to ensure that there is no movement of the switchboard when subject to a human push force of 1000 Newtons at any point.

16.7.2.1 Indoor locations

Switchboards installed in switch rooms with computer-type floors shall be installed on their own support frame bolted to the sub floor. The switchboard frame shall be sized to suit the switchboard dimensions and to allow for incoming and outgoing cable access Switchboard support frames shall be hot-dip galvanised mild steel.

16.7.2.2 Outdoor locations

Switchboards and all electrical enclosures shall not be mounted on handrails or guard rails.

Non-floor mounted switchboards shall be mounted at 1.6m above finished ground level to the middle of the switchboard.

16.7.3 Cable entries

Arrange the location and number of cable penetrations through gland plates to maximise the availability for future cable entries.

Where gland plates have limited access from below, tap the gland plate and mount the glands above it inside the switchboard. Fully seal all spare holes in gland plates. Cable glands shall be sized to allow cables to be removed with lugs still attached without removing the gland, where practicable.

All cables shall be supported and not apply tension to any terminations.

Cables shall not enter through the top of electrical equipment without written approval from Hunter Water. Where top entry is permitted, the gland plate and cable entry shall not obstruct or foul equipment and cable gland shall be fitted with appropriately sized shroud/boot to mitigate against water entry.

Cable glands shall be:

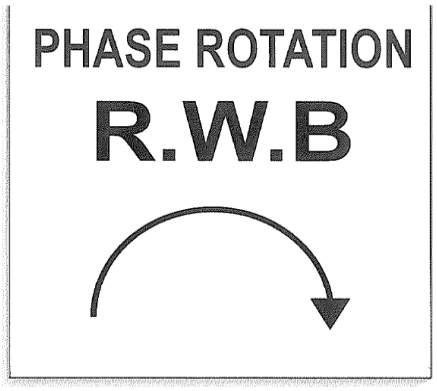
- double compression type
- IP 68 rated
- installed on the bottom of the gland plate. Where the gland plate is inaccessible glands may be rotated following Principal approval.
- fitted with boots/shrouds on all outdoor switchboards and indoor switchboards located within a dusty environment (e.g. lime and PAC rooms).
- manufactured from:
    - black UV stabilised PA66 nylon for glands up to and including 25mm
    - nickel plated brass for consumer mains cable glands and all other glands

Note for specific requirements for VSD cable glands refer Clause 15.4.7.

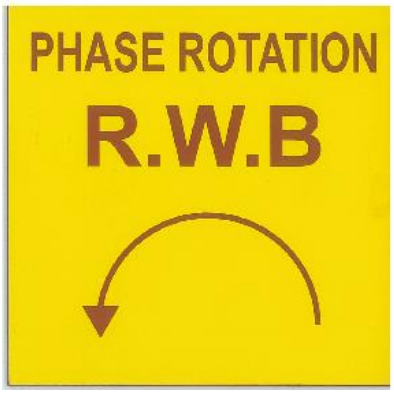
16.7.4 Phase rotation

Phase rotation on installations shall be positive. Where the positive phase rotation is impractical, a written request for exemption shall be submitted to the principal for approval. On approval being granted, appropriate labelling shall be installed. Any change required to achieve positive phase rotation shall be done on the line side of the service protection device.

All installations shall have a 100 x 100mm label, as shown below.



Positive phase rotation



Negative phase rotation

17 Switchrooms

17.1 Submissions

The following shall be submitted as part of the detailed design report:

- Calculations to demonstrate HVAC system compliance with required cooling system capacities detailed within STS 410, including detailed heat load demand in consideration of thermal, lighting and solar loading. Includes assessment of existing HVAC systems where heat generating equipment is added to a switchroom (e.g. VSD's, solar inverters or switchboards added to an existing switch room).
- Lighting study.
- Details of VSD or AHF venting systems, including dimensioned drawings and any civil/structural modifications.

17.2 General

Provision for future switchboard extensions shall be allowed for (minimum two tiers per switchboard, one tier on each end of the switchboard or two at one end on request).

Switchroom subfloor shall contain a sump with a pit float switch to register an alarm on SCADA when a pit floods.

All switchrooms shall have a single 15-inch HMI, which is typically mounted on the external door of one of the switchboard PLC cubicles.

17.3 Construction and fit out

Refer to STS 410.

17.4 Switchboard position/location

All switchboards and other fixed equipment shall be located inside switch rooms to provide safe and easy access for operation and maintenance of all equipment.

The installation of switchboards shall comply with *AS/NZS 3000* clearance requirements.

Switchroom layouts shall allow any individual switchboard to be removed from a building and later reinstated while all other switchboards and any other fixed equipment, e.g. UPS, remain in place.

18 Instrumentation, monitoring and control

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18.1 General

All instruments shall be installed as required by the manufacturer to ensure readings accurately reflect the process conditions. All instruments and associated devices supplied shall be fully supported by spare parts and technical service available in the Lower Hunter area.

Instrumentation shall contain all the necessary hardware to provide an operator with an easily accessible local indicator, either on the instrument or in the field instrument panel. Additional indicators shall be provided on PLC cabinet doors. The values on the digital displays shall coincide with the values on SCADA. Where there are more than five displays required, a 15-inch colour touch HMI screen shall be used to display these values and connect the screen to the PLC network using Ethernet.

All electrical devices necessary for process delivery shall have their status and health reported on SCADA. This includes services such as PFC, UPS, Air-conditioning, pressurisation fans.

All instruments shall be loop powered or powered from 24 V d.c. supply. Analog signal transmission shall be linear, 4 - 20mA d.c. proportional to the range of measured variable. Instrument signal cabling between the instrument and the PLC shall be protected against lightning at both ends of the circuit.

All transmitters shall be capable of working into instrument loop impedances of up to 600 ohms. All instrument loops shall perform reliably under site conditions.

Analytical instruments that require operator calibration, such as dissolved oxygen (DO), pH, and turbidity, shall have transmitters mounted in enclosures with treatment plant locks. The terminals and lightning protection units shall be located in a separate enclosure that can only be accessed by electricians. The terminal enclosure shall be labelled ‘Live terminals behind cover – isolate elsewhere before removing cover’.

All transmitters with black screens shall have suitable covers to protect screens from sunlight.

Each instrument must be able to be isolated by its own fuse or switch without interrupting or isolating any other devices.

18.2 PLC, SCADA and telemetry

18.2.1 General

Shall comply with STS 550.

All PLC digital inputs shall be 24 V d.c. and interfaced by a 24 V d.c. relay with gold-flashed contacts. A disconnect terminal shall be installed between all PLC digital inputs and the interface relay contact. All spares shall be wired to a disconnect terminal.

All PLC digital outputs shall be 24 V d.c. and interfaced by a 24 V d.c. relay. All spares shall be wired to an interface relay.

PLC analog inputs/outputs shall be 4 - 20mA, current sinking or sourcing as required and fully short circuit protected.

Each input/output point that connects to equipment in the field shall be suitably protected by a fuse.

18.3 Control and protection relays

18.3.1 Control relays

All control relays shall be 24 V d.c. and block type for all control applications.

18.3.2 Digital protection relays

18.3.2.1 General

Digital protection relays shall comply with all relevant parts of the *IEC 60255* series of standards and all relevant standards referenced therein.

18.3.2.2 Mechanical requirements

Digital protection relays shall be housed in robust cases designed to:

- Achieve mechanical robustness, as per *IEC 60255-21-1*, *-2* and *-3*.
- Achieve climatic withstand in accordance with *IEC 60068-2*.
- Maintain the IP ratings of the HV/LV switchboard enclosures.
- Provide means for easy withdrawal and re-insertion of relays for inspection and maintenance.
- Protect keypads and adjustment devices while ensuring all settings are visible from the front with all covers in place.
- Provide operation and alarm indicators clearly visible from the front and capable of being manually reset with all covers in place.

Relays shall be suitable for back connection. All connections shall be clearly identified for wiring purposes. The types of terminals for the connection of energising quantities, auxiliary supplies, tripping circuits, etc., will be subject to approval by the principal. All screw connections shall use ring lugs.

18.3.2.3 Human-machine interfaces (HMIs)

Each protection device shall include metering functions and an integral HMI (liquid crystal display and keypad) which allows an operator to view status, enter control commands, review and acknowledge alarms/trips, view measured values, enter and review setup parameters.

Separate hand-reset operation indicators shall be provided for all IDMTL and instantaneous protection elements.

18.3.2.4 Electrical ratings

Alarm and indication contacts shall be rated for duty level II B, as per *IEC 60255*.

All relays shall be suitable for 1A CT secondaries.

18.3.2.5 Protection performance requirements

The setting range of phase fault IDMTL elements shall be approximately 50 - 200% of the rated current, adjustable either continuously or in 25% maximum steps.

The setting range of earth fault IDMTL elements shall be approximately 10 - 40% of the rated current, adjustable either continuously or in 5% maximum steps.

The effective range, the minimum and maximum pick-up currents, the resetting current, the time current characteristic and the overshoot time shall correspond with the normal inverse definite minimum time lag (IDMTL) Class E7.5 characteristics, as per *IEC 60255*.

The time multiplier setting range shall be approximately 0.05 to 1.0, adjustable either continuously or in 0.05 maximum steps.

All relays shall incorporate a high-set instantaneous element as an integral part of each phase fault, earth fault, or earth fault measuring unit.

The setting range of phase fault instantaneous elements shall be approximately two to eight times rated current, adjustable either continuously or in steps no larger than 0.5 times rated current, plus infinity.

The setting range of earth fault instantaneous elements shall be approximately one to four times rated current, adjustable either continuously or in steps no larger than 0.5 times rated current, plus infinity.

The design of instantaneous elements shall be so they may be made inoperative (i.e. infinity setting) without being disconnected from the relay.

Auxiliary tripping elements, if used, shall operate in less than 20 milliseconds with the energising quantity at rated value, and shall operate positively with the energising quantity at 70% of rated value.

The design of the earth protection circuit shall be such that nuisance tripping on energisation does not occur. Where necessary, stabilising resistors shall be fitted.

Relays shall be capable of continuous service at twice setting current (any setting) and shall withstand 20 times rated current for three (3) seconds.

Relays shall be capable of providing very-inverse and extremely inverse time characteristics by simple setting, or plug changes using a purpose-built switch mechanism mounted on the front of the relay.

Each relay shall provide not less than two (2) electrically separate contacts for tripping duty.

All digital protection relays shall have event-recording capabilities.

18.3.2.6 **Communications interfaces**

Protection relays shall be connected to the PLC/SCADA/HMI system via communications interfaces.

Interfaces shall provide a means of:

- remote monitoring of digital parameters (DIs for status, etc.)
- remote monitoring of analogue parameters (AIs for voltage, current, power, etc.)

Unless specifically approved otherwise, all inputs and outputs for each tier of switchgear shall be sent/received to the PLC/SCADA/HMI system via the protection relay communications interface.

Communications protocols shall be Ethernet TCP/IP.

18.3.2.7 Programming interfaces

The protection, control and communications functions of the protection relay shall be able to be setup and parameterised by means of a laptop/notebook computer interface, as well as manually via the local HMI.

Access to the protection, control and communications parameterisation and setup functions shall be password-protected for both the computer interface and manual HMI.

18.3.3 Phase healthy (failure) relays

Relays shall monitor the 3 phases for failure of one or more of these phases, asymmetry, adjustable under voltage and adjustable overvoltage. When supply is normal, relays shall close normally open contacts to provide indication of a healthy state.

Relays shall automatically reset upon restoration of correct supply voltage and rotation.

18.4 Control switches, pushbuttons and indication

18.4.1 Selector switches

18.4.1.1 Switch mode definition

Test	local control only
Off	drive is disabled
Auto	PLC control only except for E-Stop

18.4.1.2 Switch configuration

Comply with the following for all Test/Off/Auto selector switches:

Test	toggle pointing 45^0 to the left of vertical
Off	toggle pointing vertically up
Auto	toggle pointing 45^0 to the right of vertical

Escutcheon plates shall allow function and switch position labelling to be included on the plates. Switches shall have only four mounting holes at the corners of the escutcheon plate.

Terminals shall be arranged for rear access. Side-access terminals are unacceptable.

18.4.2 Pushbuttons

The following colours shall be used for pushbuttons to indicate the function of the pushbutton:

Red	Stop/Close/Circuit breaker open
Green	Start/Open/Circuit breaker close
Black	Test/Level override
Blue	Reset

18.4.2.1 Stop buttons

Stop buttons shall be red and non-latching.

18.4.2.2 Emergency stops

Emergency stop buttons shall comply with *AS/NZS 4024.*

18.4.3 Operational indication lights

Indicator lights shall comply with the following:

- Super bright type LED type.
- Include press to test functionality.

The following colours shall be used for indication lights to indicate the function of the light:

White	Ready
Red	Running/Opened valve/Circuit breaker closed
Green	Stopped/Closed valve/Circuit breaker open
Amber	Fault/Alarm

18.5 Voltmeters and ammeters

Meters shall comply with the following details:

- flush mounting
- accuracy class 1.5 (minimum)
- minimum 72mm square bezel with 90 degree quadrant scale – all meters to be of the same style and size
- minimum of 48mm for ammeters on motor starter cells and selected so full scale is not less than the motor FLC
- operated from 4 – 20mA when mounted on cubicle doors

18.6 Power meters

Power meters shall have compatible communication capabilities so parameters are able to be monitored from a PLC/SCADA system using Ethernet TCP/IP.

Power meters shall include remote displays with the following parameters:

- voltage L-N (average, per phase)
- voltage L-L (average, per phase)
- frequency
- current (average, per phase)
- kW/MW (total, per phase)
- kvar/Mvar (total, per phase)

- kVA/MVA (total, per phase)
- kWh/MWh (total, per phase)
- kvarh/Mvarh (total, per phase)
- kW/MW (demand, peak)
- kVA/MVA (demand, peak)
- current demand (average, per phase)
- current peak demand (average, per phase)
- power factor (total, per phase)
- voltage THD (per phase)
- current THD (per phase)

18.7 Low voltage current transformers

Current transformers for electricity distributors' equipment shall comply with the requirements of the Supply Authority or Network Service Provider (NSP).

All other current transformers shall comply with the following:

- Be resin encapsulated window type and comply with *AS 60044.1*.
- Rated primary current shall have a current rating equal to the maximum current rating of the frame size of the controlling device.
- Secondary windings of measurement current transformers to be rated at 5A. The burden is to be 0.4 ohms (10 VA) minimum and the accuracy class 2 minimum.
- Be connected via proprietary shorting blocks.

Where fitted on cables, current transformers shall be installed to allow easy removal from the switchboard.

One side of all current transformer secondaries shall be connected to the switchboard main earth bar.

18.8 Underground and in-ground installations

Where process control, regulatory monitoring or critical monitoring point instrumentation is required below ground level, install within a suitably sized concrete pit with sufficient space to access and undertake maintenance. Pit size to be approved by Hunter Water during detailed design. Provide a gravity drain, where appropriate, from the pit. The open end of the pipe must be clearly marked by a fixed post with a minimum height 1m above surface level. If gravity drainage is not appropriate, install a sump 300 x 300 x 300mm. The sump shall contain an operational pump which discharges to an approved point. A pit float switch shall be installed in all pits to register an alarm on SCADA when a pit floods.

For other assets the requirement for pits shall be assessed on a case-by-case basis. Instrumentation may be direct buried if:

- the manufacturer warrants direct burial, and
- the maintenance access meets the functional requirements of the equipment, and
- Hunter Water has approved direct burying of the instrumentation

Install instrumentation below ground as directed by the specifications or drawings. The instrumentation shall have a minimum rating of IP68.

Direct burial of equipment shall be in accordance with manufacturers' requirements. In the absence of specific manufacturer requirements, the void around the instrument shall:

- Be backfilled with a packing sand mixture.
- Protected by completely packing the entire sensor (housing, bolts/nuts, and flanges) with mastic contour filler.
- Wrapped with a synthetic fabric-based tape, impregnated and coated with organic petroleum-based compounds, followed by plasticised PVC, incorporating natural and synthetic rubber adhesive and fungal inhibitor.

A polymeric cover to shield the entire instrument shall be installed 150mm below finished ground level. Hunter Water shall be notified three working days prior to covering/backfilling installations, to arrange inspection by a Hunter Water instrument engineer/technician.

18.9 Instrument loops

All instrument loops shall have as a minimum requirement the following accuracies unless specified elsewhere:

- calibration accuracy ± 0.5% of span
- repeatability ± 0.1% of span
- sensitivity ± 0.1% of span

18.10 Instrument tests

Test all instruments establishing the overall accuracy of the devices from primary element to the PLC.

Results shall be recorded on test sheets when complete. Copies of the test sheets shall be submitted within five working days and include additional copies for each copy of the operation and maintenance information/manual.

18.11 Level measurement devices

18.11.1 Ultrasonic level transmitters

Radar shall be used in preference to ultrasonic level sensors unless there are specific technical reasons for an ultrasonic level transmitter.

Ultrasonic level sensors shall be non-contact, continuous reflectance, level monitoring type complete with self-temperature compensation for changes in ambient temperatures. The transmission beam shall be appropriate for the application.

Examples of use:

- flume flow metering
- open tanks and reservoirs
- filter beds

18.11.2 Hydrostatic pressure level transmitters

Unless otherwise specified, all transmitters should be fixed range 0 – 1 bar.

Examples of use:

- sewer wet wells (small and medium-size stations), water reservoirs
- in chemical tanks if specific gravity of material is factored into displayed reading

Hydrostatic pressure level transmitters are unsuitable for high-flow sewer stations, sludge tanks, aggressive chemical storage tanks, or tanks with stirrers.

Transmitter shall be supported by stainless steel stockings. Cable ties are unacceptable. Where required, supply stilling tubes mounted to stop movement of the transducer unit due to turbulence.

18.11.3 Radar level transmitters

Receiver signals shall be software-conditioned to eliminate extraneous signals.

Examples of use:

- bulk water reservoirs
- sewer station wet wells
- chemical storage tanks

Do not use radars with stainless steel focus cones in tanks containing aggressive vapours.

If the radar unit is to be housed in a metallic enclosure, the enclosure shall be lined with appropriate RF absorption material.

18.11.4 Float level switches

Float switches shall be encapsulated submersible type, single-pole double-throw.

Switches shall be provided with sufficient length of heavy-duty flexible cable to allow a generous adjustment of the operating level. The cable length allowed for adjustment is to be neatly coiled and tied. Floats shall be supported by stainless steel stockings. Cable ties are unacceptable.

Float switches shall not contain mercury.

18.11.5 Conductivity level switches

Conductivity level switches shall not be used.

18.12 Flow measurement devices

18.12.1 Flume flow metering

Radar level sensors complete with indicating transmitters shall be provided to measure the rate of flow through flumes. Flow-measuring systems shall be designed so the highest measurement accuracy for that type of device corresponds to the most frequent flow rates to be measured.

The transmitters shall include a display showing instantaneous flow in litres per second.

For flow measurement, units shall include linearisers incorporated with transmitter units to convert the level into a 4 - 20mA signal proportional to instantaneous flow, in accordance with the type of flume being used.

18.12.2 Electromagnetic flow metering

18.12.2.1 General

The flow meter and installation shall comply with ISO 6817 and AS4747.5. Where there is a conflict in specification, the highest specification should be applied. In all circumstances the manufacturer's recommendations should be fully applied.

All meters shall comply with the metrological and technical requirements of NMI R 49-1 and shall be of an approved pattern where applicable by the National Measurement Institute.

The Electromagnetic flow meter shall be able to measure flow in both forward and reverse direction with the direction of flow indicated on the local display and by a switching contact or via a separate output signal for each direction.

The flow meter shall be suitable for use in empty pipes and have the ability to enable or disable the empty pipe alarm functionality.

All meters shall be provided with a clearly marked nameplate that contains the name of the manufacturer, measured parameter, unique serial number, model number, relevant operating parameters such as maximum pressure rating for in line instruments, hazardous area certification details (where applicable), electrical power supply voltage, frequency and loading as well as a unique identifying number or alpha-numeric identifier to be provided by HWC.

In addition to the nameplate all flow meters shall be provided with a permanently fixed stainless steel engraved tag containing the Ellipse Plant Number of the instrument.

All materials shall be new at the time of manufacture or installation.

All materials used in the manufacture of flow measurement sensors shall have the following characteristics:

- Construction materials shall be selected to provide consistent reliable operation for the life of the meter in the operating conditions
- Metal components, which are in contact with either the metered water or surrounding ground and groundwater, shall be of corrosion-resistant material or declared resistant by means of suitable coating or other surface treatment.
- All copper alloys in contact with water shall comply with AS 2345
- Materials in contact with drinking water shall comply with AS/NZS 4020
- Shall comply with HWC standards for materials in contact with potable water.
- All flow meters shall comply with AS 3565.1 in regard to material durability tests.

18.12.2.2 Location

The Flow Meter shall be installed in a pit if any one of the following criteria are met:

- The flow meter is ≤DN 300, and buried less than 1.2m, and is not in a trafficable area.
- There is a live service(s) within 5m. E.g. electrical cables, gas, fibre optic cable

- The flow meter is deemed to be a critical flow meter. This is to be determined in conjunction with a HWC representative. E.g. the flow meter is used for billing, licencing etc.
- The replacement of the flow meter would require significant disruption to the public and/or result in significant restoration costs

All other flow Meters may be buried direct and follow the subsequent guidelines:

- The flow meter must be ordered from the manufacturer complete with a proprietary sensor cable with length to suit the specific application and potted with the recommended manufactures gel to ensure IP68 requirements are met.
- The complete body of the flow sensor must be protected using “Denso” wrap even when complete immersion of the flow sensor is not anticipated. It is important to protect the flow sensor by packing the entire unit (including housing, flanges and bolts/nuts) with “Denso” mastic (400) taking care to ensure there are no air-pockets where moisture can accumulate, then wrapping the unit with “Denso” tape (600) followed by “Denso” PVC overwrap tape (931). By wrapping the sensor this protects the sensor from corrosion. If the sensor is required to be exposed in future the sensor condition will be maintained.
- In locations where there is extensive lightning activity a sensor lightning protection kit should be implemented. This lightning kit shall provide protection to the coils in the sensor.
  The earth impedance of the lightning kit connection to ground shall comply with AS/NZS 1768 so as to prevent the connected infrastructure from generating unacceptable touch voltages as specified in AS/NZS 3000. For the purpose of calculation touch voltages will be considered to be sustained for 0.4 seconds.
- The flow meter shall be earthed as per the specification mentioned below in this document.
- The flow meter shall be back filled with bedding sand to a height of 300mm above the flow meter. At this point a steel plate (minimum 1mm thickness) greater than the size of the meter with electrical warning tape shall be used to provide mechanical protection to the meter during future excavation and make operators aware electrical cables lie below.
- The flow meter shall be inspected prior to backfilling by a HWC representative

The flow sensor shall have straight pipe runs of at least ten (10) clear pipe diameters upstream after bends and tees and twenty (20) clear pipe diameters after throttling valves or an increase in pipe diameter. A downstream straight pipe length of at least five (5) clear pipe diameters shall be required. It may be necessary for some specific HWC approved installations that a minimum five (5) clear diameters of upstream and three (3) clear diameters downstream may be applied. This shall only be considered provided the manufacturer’s standard documentation states the flow meter itself is capable of performing to its stated specification in this reduced (pipe diameter clearance) installation. Meters required to measure bi-directional flow shall have a minimum clear straight pipe length of twenty (20) clear diameters on both sides of the meter.

The meter shall be the same nominal diameter of the adjoining pipeline. If it is required to reduce the pipeline diameter to match the selected meter diameter, reducers (approved by meter manufacturer) shall be installed upstream and downstream of the required straight pipe lengths (not directly upstream and downstream the meter). Meter manufacturer advice shall be sought in relation to any minor difference between actual internal diameters.

The designer shall consider the influence of associated infrastructure with regards to uniform flow profile (such as pumps, pressure regulating valves, mixers, two bends in different planes) in addition to the nominated straight pipe length requirements. The designer shall ensure the installation meets the meter manufacturer’s requirements for uniform flow profile.

The meter shall be installed a minimum of 20 diameters upstream of chemical dosing points where possible. If unable to install the meter upstream of a dosing point, the meter shall be no less than 50 x diameter downstream of the dosing point and the fluid shall be well mixed. Considerations shall be made to ensure the internal components are compatible with the chemical being dosed.

The designer shall consider potential influences of electromagnetic interference in the design of the meter installation, with specific note for the potential for pipelines to raise to LV phase voltage during a domestic service neutral fault.

Other than those approved by the meter manufacturer, no structures or wiring shall be in contact with the meter.

Meters installed in parallel or in series shall meet the meter manufacturer's segregation requirements.

18.12.2.3 Size

The designer shall consider the operating flow range when selecting the diameter of the meter. The accuracy of the meter shall be maximised as much as practicable.

The meter diameter shall be selected to ensure that the flow rate (through the meter) during operation is as follows:

- Pumped system: flow rate shall always be above the Q2 of the selected meter except during start up and shutdown.
- Gravity / demand driven system: for the majority (i.e. greater than 50%) of the operating time, and volume transfer, the flow rate shall be above the Q2 of the selected meter. Operating flow rate below Q2 should be minimised as much as practicable. The estimated volume which will be transferred below Q1 and Q2 flows shall require the approval of HWC.
- For any installation, consideration must also be given to the maximum flow rate in order to ensure the meter is appropriately sized. The maximum allowable operating flow cannot be above Q3, except for short periods up to Q4.

Note: The specific flow rates corresponding to the various flow designations are provided by the meter manufacturer. A smaller diameter meter will generally have a lower Q2. Refer to NMI R 49 for full definitions of the various flow designations.

It is accepted that the calibrated accuracy of ±0.2 % does not apply at minimum flow conditions, instead the NMI / OIML R 49 maximum permissible error limits shall apply.

In the case that a meter does not have a nominated Q2 value, the following conditions shall be met during operation:

- Pumped system: velocity shall always be above 0.1 m/s except during start up and shutdown. Velocity shall be no less than 0.5 m/s for the majority of the operating time and volume transfer.
- Gravity / demand driven system: velocity shall be no less than 0.5 m/s for the majority of operating time and volume transfer. Operating velocity below 0.5 m/s should be minimised as much as practicable. The estimated volume which will be transferred below 0.1 m/s and 0.5 m/s flows shall require the approval of HWC.

It shall be brought to HWC's attention if a single water meter is not suitable for the range of system operating flow conditions. In such cases an alternative metering installation may need to be considered and shall require approval from HWC.

18.12.2.4 Flow Tube Liner and Electrodes

Only liner material that complies with Australian Standards / Hunter Water specifications for materials in contact with potable water or wastewater shall be used.

18.12.2.5 Process Connections

Electrode material such as 316 stainless steel, Hastelloy C or platinum iridium shall be used and shall be of a type that does not require cleaning. The electrode material chosen shall not be detrimentally affected by the process fluid.

The flow tube shall be flanged and have a pressure rating which meets the requirements of the hydraulic pressures stated in the instrument datasheet and shall have a minimum pressure rating of PN16.

The manufacturer shall provide a reasonable clearance behind the rear face of the flange to allow access for installation and removal and shall be installed with a form of dismantling joint.

18.12.2.6 Submersion

For installations where there is any possibility of flooding the degree of protection shall be to IP68 at a depth of 7m in accordance with AS 60529. This protection shall be maintained under all operating and fault conditions.

18.12.2.7 Mounting

The transmitter shall be suitable for remote mounting using methods that do not compromise the ingress protection of the enclosure.

All flow meters shall be supplied with all installation brackets, supports, cables and accessories that are required for the normal operation of the flow meter.

All instruments shall be mounted securely such that there is no vibration or other external factors compromising the flow meters operation. Precautions shall be taken to prevent damage to the meter due to adverse hydraulic conditions (e.g. cavitation, surging or water hammer).

Upstream and downstream pipes shall be adequately secured to ensure no undue stresses to the flow meter and to allow for easy removal of the flow meter.

The flow tube shall only be installed after the final pipe work cleaning and flushing has occurred

18.12.2.8 Accuracy

Flow meters shall have a calibrated accuracy within ±0.2 % of the measured value under factory (laboratory) conditions. The performance of the meter shall be defined and documented in an individual calibration certificate, supplied with the meter. The calibration facility shall be accredited by NATA or an equivalent accreditation body recognized by the ILAC-MRA.

The flow meter shall have the capability to adjust low flow cut off between 0 to 10%.

The flow meter shall have the capability to adjust damping from 1 to 30 seconds.

18.12.2.9 Electrical Installation

Meters shall operate from a 24 V d.c. power supply. Where practicable, this 24 V d.c. supply will be supported by a 24 V d.c. uninterruptable power supply (UPS).

Flow meter signal output shall be HART 4 - 20mA with Pulse/frequency output.

The flow tube coil excitation shall be a square wave bipolar pulse system.

The meter transmitter shall provide the following inputs to the PLC as a minimum:

For unidirectional flow:

- Flow rate (analogue)
- Totalised volume increment (pulse digital)
- General fault (digital)

For bidirectional flow:

- Forward flow rate (analogue)
- Reverse flow rate (analogue)
- Forward totalised volume increment (pulse digital)
- Reverse totalised volume increment (pulse digital)
- Forward/reverse (digital)
- General fault (digital)
- Forward and reverse flow rate and total volume may be derived in the PLC via flow direction status signal where discrete outputs from the meter transmitter are limited.
- Any volume calculation required within a PLC shall be performed by the PLC receiving the pulsed output from the meter. Only Hunter Water's standard library PLC Derived Function Totaliser Block shall be used to perform this function. Successive downstream PLC's, SCADA system, or other remote devices shall not be used to perform this calculation.

The flow meter shall include an integral or remote digital indicator calibrated in engineering volumetric flow rate units (L/s) for all applications. The flow meter indicator shall display:

- instantaneous flow
- totalised flow
- Forward and reverse flow indication (for bidirectional flow meters)

The SCADA system (where both forward and reverse flow exist) shall clearly and concisely display whether the flow is in a forward or reserve direction.

18.12.2.10 Cabling

The flow tube shall be supplied complete with the cable connected with a length to suit the specific application. The flow tube cable shall be factory terminated to the flow tube, and factory potted with glands installed. Non-setting re-enterable gel, such as Sylgard 527 or equivalent shall be used for sealing and protecting the flow tube cable connection. All spare cable entries to be plugged with a stainless steel plug.

Electrical connections between the flow sensor and a remote transmitter (if applicable) shall be no more than 50m or the maximum cable length nominated by the meter manufacturer, whichever is shorter.

No cable joints shall be permitted on the sensor cable between the transmitter and the flow tube.

Interconnecting cables between the flow tube and transmitter shall be of a cable type recommended or mandated by the manufacturer. All interconnecting cables shall be installed in Heavy Duty conduit.

Electrical and control works shall comply with the HWC standard specifications.

18.12.2.11 Earthing

The manufacturer's requirements for earthing shall be followed carefully. Piping should always be earthed. A continuous electrical contact to the same earth potential is necessary between the flowing liquid, the piping and the flow meter. This connection shall be achieved using metallic earthing rings between the upstream and downstream pipe flanges and equipotential bonded via the use of minimum 6mm earth cable.

To provide electrical continuity along the pipeline, the pipe on either side of the flow tube will be connected with an insulated cable minimum 6 mm.

18.12.2.12 Diagnostics

All electromagnetic flow meters shall be provided with on-board diagnostics that can monitor the process and its own operability. In addition to this, diagnostic dependant messages shall be displayed or available via external communication tools to assist with troubleshooting in the event of an error.

18.12.2.13 Testing / Verification

Flow meter performance and functionality checks shall be possible without dismantling or removing flowmeter from the process. All equipment necessary to carry out verification/testing shall be provided to allow comparison of the flowmeter accuracy and performance against the original factory certification. The original factory certification parameters shall be recorded within non-volatile on-board memory such as EEPROM at the time of calibration and certification in the factory such that power loss or battery expiration will not erase or alter calibration data, total flow record or other parameters. The verification system must be able to be referenced back to the original factory calibration.

The flowmeter shall be supplied with a three-point calibration certificate undertaken by a NATA or equivalent accredited flow meter test rig. Each flowmeter shall be supplied with a unique calibration test certificate which records the flow meter model, serial number, test facility and date of test along with the documented test data and calibration result table.

18.12.3 Thermoelectric flowmeters

Airflow measuring devices shall consist of a flow element and a transmitter.

The flow element shall be manufactured from 316 grade stainless steel and sized to suit the pipe and flow requirements.

Units shall be displayed in normal cubic metres per hour (Nm^3/hr).

The overall accuracy of transmitters and sensors shall be better than ± 3% of reading, repeatability ± 1% of reading, and turndown: 5:1 to 150:1 maximum.

Example of use:

- Air-flow measurements from blowers

18.12.4 Thermoelectric flow switch

Thermoelectric flow switches may be used for flow indication in situations where there is no requirement for an analog flow rate signal.

Associated indicating transmitters shall be of electronic solid state type with adjustable signal damping.

Indicating switches shall have adjustable response times to dampen rapid flow fluctuations.

Units shall transmit TTL signals or contact closure to the PLC equipment.

Equipment shall operate from 24 V d.c. supply.

Example of use:

- process dilution water or cooling water flow indication

18.12.5 Mass flowmeters

Mass flowmeters shall be installed where accuracy is required for chemical dosing and use a Coriolis flow measurement.

Example of use:

- WTP alum and poly dosing quantity control

18.13 Pressure measurement devices

18.13.1 Differential pressure transmitter

All wetted parts, connecting flanges, nuts bolts and washers shall be manufactured from 316 grade stainless steel.

Associated indicating transmitters shall be of electronic solid state type with adjustable signal damping, span and zero-level adjustment. The unit shall incorporate a digital indicator.

The indicating transmitter shall have an adjustable response time to dampen rapid level fluctuations.

Impulse lines from pipework to the transmitter shall be minimum 8mm diameter. All impulse lines shall drain to the pipeline connection.

Examples of use:

- filter bed loss of head
- filter monitoring

18.13.2 Pressure switch

Flange mountings shall be used where the liquid being conveyed in the pipe is sludge.

Examples of use:

- low or high suction pressure in water pump stations
- low air pressure on plant air systems

18.13.3 Pressure sensor/transmitter

The associated indicating transmitter shall be of the electronic solid state type with adjustable signal damping, span and zero-level adjustment. The units shall incorporate digital indicator/programmer units calibrated in kPa and shall be mounted close to the sensor, within safe and easy access for operators.

Indicating transmitters shall have adjustable response times to dampen rapid level fluctuations.

Examples of use:

- zone water pressure measurement
- use on suction and delivery pressures at water pumping stations
- reservoir level
- water main pressure
- air pressure

18.14 Analytical measurement devices

18.14.1 Dissolved oxygen (DO) measurement devices

Temperature compensation shall be included in measuring systems.

Convert signals derived from DO sensors to an isolated 4 - 20mA d.c. output current linear with DO concentration via a signal converter. Isolate all input circuits from the mains supply and output circuits.

Example of use:

- WWTW aeration tanks

18.14.2 Redox measurement devices

Temperature compensation shall be included in measuring systems.

Convert signals derived from sensors to an isolated 4 - 20mA d.c. output current linear with the redox measurement via a signal converter. Signal converters shall include integral Redox indicators. Isolate all input circuits from the mains supply and output circuits.

Example of use:

- anoxic zone and the anaerobic zone of the bioreactors WWTW

18.14.3 pH measurement devices

The pH measurement equipment shall include either single combination electrodes or discrete measurement and reference electrodes.

Reference electrodes shall be sealed, gel-filled and non-flowing with ceramic or similar junctions that resist fouling.

Protection rating of the electrode housing shall be class IP68. Mount the electrode assembly in a flow-through type sensor housing manufactured from glass fibre reinforced polypropylene or similar.

Include in the electrode housing a sealed high impedance amplifier for all pH signals transmitted over low impedance circuits and temperature compensation in the measuring system.

Examples of use:

- WTP lime and caustic dosing control
- WWTW chemical dosing

18.14.4 Turbidity meters

Turbidity meters shall be provided with secondary standards, and user-configurable parameters shall be retained in the meter's memory when the unit is depowered.

It is an essential criterion that the displayed turbidity value and the analog outputs can be trimmed at the operator interface without the need for a full calibration using primary standards and able to be trimmed regardless of value.

Temperature signals shall be transmitted in addition to turbidity signals.

Transmitters shall include digital filter functions and sensor self-monitoring.

Examples of use:

- WTP raw water
- WTP clear water
- WTP filtered water

18.15 Temperature measurement devices

Temperature measurement devices shall be the resistance thermometer type.

Detectors shall include three-wire platinum resistance temperature detectors. Sensing elements shall be sealed in ceramic formers and enclosed in 316 stainless steel sheaths.

Sensing currents of up to 10mA shall not have significant effects on accuracy.

Transmitter enclosures shall include suitable converter heads with signal converter electronics segregated to allow wiring termination and calibration without exposing electronics.

Examples of use:

- WWTW sludge digesters
- weather station air temp

18.16 Instrumentation indicators

18.16.1 Indicators

Indicators shall be digital loop powered type meters suitable for flush panel mounting.

Indicators shall have an input range of 4 - 20mA and engineering units as required. Appropriate labels shall be installed detailing the value being displayed and the engineering units. Accuracy and repeatability shall be ± 0.2% minimum.

Indicators shall be mounted in individual instrument cases with front bezel and rear screw terminals for connection of wiring. Adjustment of zero and span shall be at rear, accessible without removing the indicator from its case.

Do not mount indicators on or through door-viewing windows.

18.16.2 Current to current converters

Provide converters wherever the loop impedance of the load devices exceeds the source device capabilities. Converters shall be fully solid state capable of receiving 4 - 20mA and provided for current isolation and as a source of power for repeating current signals.

Converters shall be powered from 24 V d.c. and shall be capable of supplying 20mA into a loop resistance of 900 ohms. Front panel adjustments for span and zero shall be provided via 10 turn potentiometers. An LED shall indicate output loop current.

Current to current converters shall be installed on horizontal DIN rail and a DIN rail terminator shall be installed between each isolator to provide an air gap for cooling.

- accuracy ±0.15% of span
- repeatability ±0.1% of span
- input impedance 50 ohms
- auxiliary voltage for input loop 22 volts at 25mA

18.17 Solenoid valves

All solenoid valve coils shall operate on 24 V d.c. supply. Written exemption from the Principal is required to operate at any other voltage.

The solenoid shall have a varistor, flyback diodes and safety fuse. All coils shall be continuously rated 24 V d.c. with protection to IP65, as per *AS 60529*.

All solenoid coils shall be plug-in type.

Coil replacements must be possible without shutting off water supply to the valve.

19 Cables and wiring

19.1 General

Cabling shall be minimum V90-insulated with stranded tinned copper conductors unless noted otherwise within a specific section of this STS.

Where cables are in hazardous gas locations, all terminations shall be made using fittings suitable for the area.

Conductors shall be terminated either into tunnel type connectors or by suitably sized lugs crimped by a correctly sized tool. Joints in cables shall not be made between equipment terminal connections.

Terminate all spare cores in terminal strip complete with cable identification ‘spare’.

Cable data sheet to be supplied as part of the design. Photos of cable labels to be supplied as part of the design.

19.2 Cable identification

Each end of every cable shall be identified with a numbered cable tag in accordance with the cable schedule.

Cable tags must be installed external to the equipment/panel. For switchboards where there is a requirement to lift floor tiles or open plinth doors to access cable tags, a tag shall be installed internal and external.

Cable tags shall be manufactured as follows:

- Outdoor: cable tags shall be 316 stainless steel and attached using stainless steel cable ties.
- Indoor: cable tags shall be pre-printed PVC cable tags with PVC cable ties.

All power cable cores shall be identified at each termination by the appropriate red, white and blue phase colour, with black for neutral. Every cable core with the exception of earth conductors shall be fully identified at both ends with ‘Multi-mark’ type ferrules numbered in accordance with circuit diagrams.

All earth conductors shall be identified at each termination by the colour green or green/yellow and shall be ferruled with the cable number. Other colours or sleeving of cables are unacceptable.

19.2.1 Cable numbering

For treatment plants, the cables shall be identified with a prefix according to the P&ID number and a suffix representing the cable number, i.e. ****- P* for power cables, ****-C* for control cables etc.

For standard network sites (e.g. pumping stations, PRV’s, reservoirs etc.) the cables shall be identified with a suffix representing the cable number, i.e. C* for control cables, P* for power cables etc.

Note: Where single core cables are installed these shall include a phase colour suffix. i.e. For treatment sites: ****-P*-R*, ****-P*-W*, ****-P*-B*, For standard network sites P*-R*, P*-W*, P*-B*.

Examples of cable types:

	Consumers mains

P	Sub mains
	Final sub circuits
	Device power supplies (any voltage)
	Motor cables
	Motor cables with pilot cores

C	Field devices not containing instrument analog loops
	Cables containing ELV power supply and control to field cabinets
	Cables containing control and instrument analog loops
I **(Note at network sites use 'C' in lieu of 'I')**	Instrument analog loops
	Instrument cables not associated with drives
D **(copper or fibre)**	Office networking
	Control system networking
	Telemetry antennas
E	Power earths
	Safety earths
	Equipotential bonding

19.2.2 Wire numbering

Refer to *STS 904 – Preparation of Electrical Engineer Drawings* to determine wire numbering.

19.3 Wiring to instruments, equipment and switchboards

Connecting wiring to instruments, equipment or switchboards shall be made using a gland and not compromise the IP rating of the instrument, equipment or switchboard being connected.

Wiring shall be enclosed in a smoothbore heavyweight PVC flexible conduit (e.g. Flexicon, Rhinoflex or approved equivalent) when installed under the following conditions:

- exposed to sunlight or other sources of UV radiation.
- permanently connected equipment that vibrates or may be moved for adjustment.

Where flexible conduit is required to be installed it shall terminate not more than 15mm prior to entering the instrument, equipment or switchboard. A boot/shroud shall be installed over the gland and flexible conduit to completely cover the wiring.

Wiring to permanently connected equipment which vibrates or may be moved for adjustment shall have multi-stranded flexible conductors. Install a cable loop ('pigtail') at the final field connection for all cables with a bending radius of less than 150mm.

An isolating switch shall be installed adjacent to each permanently connected piece of equipment and shall be located within 2000mm of the equipment at approximately 1200mm above floor. The switch shall be mounted so that the equipment or part thereof can be readily isolated and/or removed for maintenance without interference to fixed wiring.

19.4 Final sub circuit wiring and field control cabling

Wiring shall be multi-strand and minimum-size conductors shall be as follows:

Power circuits	2.5mm^2, copper conductors
Lighting circuits	1.5mm^2, copper conductors
Motor circuits	2.5mm^2, copper conductors
Control circuits	1.0mm^2, copper conductors

Final sub-circuit wires shall generally be terminated in tunnel type connectors. Where stud or pillar connections are made, stranded conductors shall be prevented from spreading. Twisting multi-stranded conductors is not a suitable method of termination except for socket outlets, light switches and similar devices.

Final connections to equipment having parts of the surface at a temperature greater than the temperature rating of the circuit cable shall be made with cable having insulation at least rated to 200°C maximum operating temperature (e.g. heater elements, hot plates, etc.).

Field control cabling must only be run as multicore control cabling with 25% spare capacity. Power cable (red, white, blue, black, Earth) must not be used as control cabling.

19.5 Field cable colours

Colour identification is standard across all HWC sites for both switchboard and field installations (refer Section 16.4.2).

Dispensation from the use of standard colours in field applications is provided as follows:

- phase wiring (A, B and C) – Brown, Black, Grey for pre terminated flexible motor cables
- ELV d.c. positive – White or Black when used in multi core control cables, individual core must be identified throughout the length of the cable
- ELV d.c. negative – White or Black when used in multi core control cables, individual core must be identified throughout the length of the cable
- Proprietary moulded instrument cables.

19.6 Cable specifications

19.6.1 Single cables in enclosures

Cables shall be insulated with 0.6/1kV grade with minimum V90 PVC insulation.

19.6.2 Underground grade insulated and sheathed cables

Cables shall be insulated with 0.6/1kV grade with minimum V90 or XLPE insulation and PVC-sheathed.

Cables shall have the manufacturers' names, reference and the word 'Underground' clearly indented in the sheathing.

19.6.3 Armoured and sheathed cables

Cables shall be insulated with 0.6/1 kV grade with minimum V90 or XLPE insulation and shall have armouring of galvanised steel wire with PVC sheathing.

Armouring shall be in a purpose-built gland that connects the armouring to earth. It shall not be used as an earth conductor.

19.6.4 Mineral insulated metal sheathed cables (MIMS)

MIMS cables installed underground or in metal pipes shall be PVC covered.

Follow cable manufacturers' recommendations for cutting, sealing and potting cable ends.

Terminations of MIMS cables entering metal enclosures, e.g. switchboards, shall be by universal glands screwed into a non-ferrous plate secured to the enclosure. The sheath shall be earthed to this plate via suitable locknuts and washers.

Where dissimilar metals are likely to touch the cable sheath, a protective barrier of PVC or similar material shall be provided between them.

The insulation resistance of MIMS cables shall be tested at the time of termination, and 24 hours later. Submit a copy of test reports within one week of testing. The resistance shall be not less than 100 megohms.

19.6.5 Aerial cables

Low voltage cables shall be insulated (aerial bundled cables).

An exception to insulated aerial low voltage cables may be granted where low voltage cables are installed on poles that also have bare high voltage conductors in Hunter Water's Tomago bore fields network. Approval from Hunter Water must be granted prior to completion of design.

19.6.6 Emergency systems and essential service cables

Cables supplying power to designated emergency systems and essential services shall consist of MIMS copper conductor copper sheath cables.

Where a number of services cross or follow a similar route, the emergency system/essential services cable shall be located at the highest point and closest to the structural support.

Use metal cable fixings. Nylon or plastic material for cable fixings are unacceptable.

19.6.7 Telephone cables

Cables used for communications purpose shall be multi-pair telephone cables of nominal conductor diameter 0.4mm^2, minimum to Telstra and/or AS/ACIF specifications.

19.6.8 Fire alarm cables

Cables used for the connection of thermal, smoke and manual fire detectors, or other associated equipment within buildings shall be TPS minimum 1.5mm^2 250V grade stranded copper cable and shall have red sheathing.

19.6.9 Security cables

Cables used for window and door seals, and associated equipment shall be minimum 0.5mm^2 stranded copper cable.

Cables for space detectors (ultrasonic, infra-red, microwave, etc.) shall be minimum 0.5mm^2 stranded copper shielded twisted pairs or as per manufacturers' installation requirements.

19.6.10 EMC Cables

Cables and cable glands used for VSD motor drives shall be in accordance with drive manufacturers' recommendations. Braided, screened power cables shall be used between the VSD and motor. Tape type screens are not acceptable.

Cable screens shall be terminated strictly in accordance with manufacturers' recommendations. All terminations shall maximise termination surface area (circumference clamping) and shall be bonded directly to the VSD dedicated earth connection facility. Braids screens shall not be extended for the purpose of earth connection, nor bundled with other screens, nor terminated into compression lugs.

19.6.11 Instrumentation cables

The cables to be used shall be PVC-insulated and sheathed with an aluminium Mylar screen and base copper drain wire.

The cable shall be overall screened, or individual and overall screened, dependant on the application. Where individual and overall screened each screen shall include a dedicated copper drain wire. The cable shall consist of pairs of seven strands of minimum size 1.5mm^2.

Cable pairs shall be twisted and identified either by colours or numbers embossed on the PVC insulation.

Analog signals and digital signals shall be run in separate cables.

Screens shall be connected to earth at source end only. The screen shall be continuous from switchboard to device, including through junction boxes, and be insulated from earth. Where terminated, screens shall be fitted with clear sleeving and ferruled with the cable number.

19.6.12 Submersible pump cables

Submersible pump cables shall be supported by stainless steel stockings.

Where pumps have more than one power cable, the stockings shall be connected using a D-shackle and a single sling used to connect them to the hook.

When installed in pumping stations with two or more pumps, the submersible pump cables shall be long enough to allow connection to other cable connection boxes, or the other starters within the switchboard.

19.6.13 Optical fibre cables

Optical fibre cables shall meet the following requirements:

- All new fixed cabling between communications cubicles or floor distribution closets shall be optical fibre, in multimode up to 500 m, and then single mode at distances greater than this
- the multimode standard is OM3 (50/125µm) in new installations
- OM1 and OM3 cabling shall not be mixed in the same segment of the network. They must be segregated by an active network device, e.g. PLC rack converter module, switch, router, etc.
- the cables shall contain a minimum of 12 cores, and shall be terminated to patch panels at both ends; SC connections for OM1, and LC connections for OM3. Test results shall be supplied to the Hunter Water Representative
- SCADA and control networks shall not share the same physical optical fibre cables
- optical fibre cables that form different sections of a ring topology shall follow separate physical paths and be spaced a minimum of 600mm from each other until after entry into the destination cubicle
- optical fibre cables shall have a minimum of 2m spare looped prior to termination in the sub-floor/cable zone/etc., and a minimum of 1m spare looped in every cable pit they pass through
- patch panels for 19” racks shall be withdrawable cassette tray types with 20% spare capacity.
- All optical fibres shall be fully enclosed in conduit as they leave a switchboard or cabinet. The conduit shall commence 250mm above the gland plate inside the cubicle.
- The optical fibre cables shall be labelled where they pass through electrical pits with warning marker tape. The tape shall have words similar to ‘Caution – Optical fibre cable – Do not disturb’. As a minimum, the optical fibre cable shall be enclosed in corrugated conduit where it passes through electrical pits, and shall be installed so the fibre is laid around the edges of the pit to prevent or minimise the possibility of cable being damaged while anyone is working in that pit.

19.6.14 Copper Ethernet cables

Copper Ethernet cables shall meet the following requirements:

- CAT 5e/6 cable is to be used in the communications cubicle
- CAT 5e/6 STP cable is to be used outside the communications cubicle where interference is possible, e.g., from VSDs and/or IMCCs in the same area. It shall contain both an overall braid screen and foil shield with unscreened twisted pairs. This cable may also be referred to as SF/UTP.
- CAT 5e/6 cable is not to be used between buildings/plant areas. Optical fibre cables shall be used between buildings/plant areas.
- All cables shall be terminated at both ends to either patch panels or telecommunications outlets (UTP/STP) excluding VSD communication cables. There shall be one spare telecommunications

outlet per physical destination; for example, a wall in a switchroom, so that every Ethernet-connected device can reach a spare outlet within the maximum patch lead length, while allowing for safe routing of the temporary patch lead. The fixed cables can be blue, black, or grey in colour.

- All cables and terminations are to be clearly labelled at both ends to facilitate identification.
- No patch leads (optical fibre or copper) are permitted between communications cubicles or floor distribution closets and other cubicles containing active equipment. Patch leads are only permitted internally within cubicles, or externally from wall mounted telecommunications outlets to devices and between devices in RSTP configurations.
- The patch lead shall be factory certified, flexible, and green in colour.
- Where an 'Ethernet cross-over cable is required, it shall always be red in colour, regardless of its use.

19.6.15 Serial Communication

All serial communication 'fly leads' and 'patch leads' used for automation equipment (including, but not limited to, PLC, HMI, SCADA, Gateway communication devices, VSD, and like automation items) shall be coloured white or cream. The only exception to these colours shall be proprietary leads supplied by the manufacturer for specific use on their equipment.

19.6.16 Coaxial Cable

All coaxial cables used for Telemetry applications shall be 50 ohm impedance.

Coaxial cables used for ultrasonic flow meter applications shall have an impedance as defined by the flow meter manufacturer.

Coaxial Cable for Telemetry applications @512MHz shall comply with the following tables. Note for modems at 700-900MHz multiply the 512MHz value by 0.8 to obtain the maximum cable length in metres.

Fly leads		
Application	Cable between device and surge diverter	
Cable type	9006 (RFI)	8223 (RFI)
Preferred max length (m)	<1.5m	
Maximum length (m)	2m	5m

Antenna feeder cable				
Application	Cable between surge diverter and antenna			
Cable type	8213 (RFI)	CNT-400 (RFI)	LDF4-50A (RFI)	AVA5-50FX (RFI)
Preferred max length (m)	<12m	<20m		
Maximum length (m)	15m	25m	50m	90m

Coaxial Cable for Flow meter applications shall comply with the following table.

Ultrasonic Flow meter	
Application	Cable between ultrasonic probe and transmitter

Cable type	RG6 Quad Shield	Other Coaxial As per flow meter manufacturer recommendation
Maximum length (m)	As per flow meter manufacturer recommendation	As per flow meter manufacturer recommendation

For cable lengths in excess of those given in the tables above, contact Hunter Water Representative for advice. Note for cable types/distances not listed the above tables, the loss over the cable length shall not exceed 2.5dB at the relevant frequency.

19.7 Reticulation wiring

19.7.1 General

All equipment installed shall be selected, sized and installed to current Australian standards. The location of the cable routes shown in drawings is approximate. It is the contractors' responsibility to determine the exact route of cables.

All cabling shall be installed underground unless specified otherwise. Cables shall be installed in underground conduits between sections of plants. All above ground installations shall be approved prior to installation.

All cable tray, conduit or wiring shall not be positioned in a location such that it may cause a step, trip, inconvenience to operation or maintenance

19.7.2 Segregation

All power, control, instrumentation equipment wiring and terminals shall be physically segregated from each other. Access to one shall not be through the other.

All terminations of mixed voltages shall be segregated and grouped according to voltage, with barriers on both sides and labels affixed indicating the appropriate voltage (e.g. 24 V d.c., 230 V a.c.).

19.7.3 Mechanical protection

Supply and install mechanical protection on all cables, cable ladders, conduits and electrical equipment under the following, but not limited to:

- From ground level to 300mm above any floor, walkway or concrete surface
- where subject to risk of damage during normal plant operation and maintenance
- on which scaffolding or planks may be placed

Sheet metal covers installed to provide mechanical protection shall be:

- Constructed from grade 316 stainless steel or aluminium, of minimum thickness to withstand the shock loading likely to occur in the area (minimum thickness 5mm).
- Constructed to enclose the equipment and associated conduits.

- Designed to provide adequate ventilation and light to prevent vermin making nests behind them, while still providing mechanical protection and shading from sunlight.

Any device installed for the mechanical protection of conduits and/or cables shall be free of burrs and sharp edges. Additional bushing or sleeving shall be provided as required to prevent conduit and/or cable damage.

Covers protecting cables shall be stopped below the connection enclosure to allow cable numbers to be easily read without the removal of the cover.

19.7.3.1 Pump station trench covers

Pump station trench covers, shall be constructed of GRP e.g. 'tread deck' or equivalent. Where this can't be achieved covers shall be constructed from minimum 5mm grade C5251-H34 aluminium and include a 6mm^2 flexible earth lead with a countersunk bolt to avoid trip hazards that is connected to the switchboard earth bar.

19.7.4 Underground reticulation

19.7.4.1 General

All cables to be run underground shall be enclosed in conduits.

Conduit runs are to be designed and installed to achieve a minimum 30% total spare conduits based on the largest conduit size installed per run.

Details of spare conduit quantities are as follows:

Used Conduits	Spare Conduits Required
1	1
2	1
3	1
4	2
5	2
6	2
7	3
8	3
9	3
10	3
11	4
12	4

For example:

- If 8 x 100mm used conduits are installed between 2 pits, an additional 3 x spare 100mm conduits are required (11 conduits total).
- If 4 x 100mm & 4 x 80mm used conduits are installed between 2 pits, an additional 3 x spare 100mm conduits are required (11 conduits in total).
- If 2 x 50mm used conduits are installed between a pit and the final equipment location, an additional 1 x 50mm spare conduit is required (3 conduits in total).
- If 1 x 50mm & 1 x 32mm used conduit are installed between a pit and the final equipment location, an additional 1 x 50mm spare conduit is required (3 conduits in total).

Conduits shall not run lengthwise under roads. Where conduits cross roadways they shall be installed at 90^0 to the roadway.

Cables throughout the site shall be segregated into conduits allocated to the following groups:

- HV power
- LV power
- Consumer mains
- 24 V d.c. control cables, thermistor cables, instrumentation cables, potentiometer cables etc.
- Communication cabling including optical fibre cables

Where reticulation systems include optical fibre, a marker tape with metal trace shall be installed. The marker tape ends shall protrude into the cable pit to enable connection to cable-tracing equipment.

Do not order cables nor commence excavation work before a confirmation of conformity to the design submission is received.

19.7.4.2 Trenching

The work associated with trenching shall include clearing, grubbing, excavating, filling, and consolidating the trench and all necessary pumping, drainage, shoring, and bracing.

Where crossing or running parallel to other services underground cabling shall be spaced as per *AS/NZS 3000*.

Comply with the requirements of telephone, gas, water, and sewerage authorities.

When crossing concrete or bitumen surfaces, cut the surfaces in a straight line with a masonry saw. Cut to a minimum depth of 75mm, or the full depth of the surface coat, whichever is greater.

Where solid rock is encountered, cables may be chased into rock.

Minimise disturbance to tree root systems. Roots of 75mm diameter or larger are not to be severed.

19.7.4.3 Inspection of trenches

All cable trenches shall be made available for inspection at the following stages:

- after laying the conduit, but before any backfilling
- after laying covers or marker tape

Give at least two full working days' notice prior to the programmed backfilling.

19.7.4.4 Backfilling and reinstatement

PVC conduits shall be bedded in compliance with *AS/NZS 3008.1.1* before backfilling the trench.

Cover conduits with stone-free spoil removed from the trench. Beach sand is not to be used for either bedding or backfilling.

Lay cable marker tape as per AS/NZS 3000 for the full length of all underground conduits.

After laying the conduits in unpaved areas, the trench shall be backfilled and consolidated to about 100mm above the natural ground level. Remove all excess spoil and dispose of in accordance with the contractor's environmental management plan.

Existing grassed areas shall be backfilled and turf re-laid on a prepared bed to about 100mm above natural ground level.

In existing concrete or brick paved areas, the trench shall be backfilled with clean sand to the underside of the reinstated pavement and consolidated by watering and mechanical compaction. Reinstate surfaces to match the existing surface level.

In existing bitumen paved areas, the reinstated surfaces shall be cambered so the edges are flushed and the centre is 10mm above the existing pavement. A minimum of the top 150mm immediately below the bitumen shall consist of finely crushed gravel mechanically compacted into the trench. The existing bitumen edges of the trench shall be prime coated with bitumen prior to laying 75mm minimum of hot premix bitumen to the finished cambered surface. The repair procedure and materials shall be in accordance with the requirements of the authority responsible for the road.

19.7.4.5 Underground cable protection

Where additional cable protection is required it shall be polymeric type. Marker tape shall comply with AS/NZS 3000

19.7.4.6 Underground cable draw-in pits

Locate draw-in pits:

- at changes of horizontal direction of cable routes greater than 15 degrees.
- at low points
- immediately prior to cables entering or exiting buildings. An exemption may be requested in writing, but is not guaranteed to be granted, for specific installations where a cable pit is not practical.
- at a spacing of not greater than 50m on treatment plants or pump stations
- at a spacing not more than 125m for reticulation outside treatment plants or pump stations

Pits shall be proprietary fully enclosed concrete type and include a dedicated drainage hole in the base. For dual conduit runs, moulded PVC pits can be used following approval from Hunter Water.

Where concrete risers are installed the join shall be made watertight using a sealant mastic or manufacturer approved alternative product.

Install proprietary pits in accordance with the manufacturers' instructions on a minimum 100mm thick bed of 20mm coarse aggregate, as per *STS 101 – Construction and Pipe Bedding Materials*. The bed shall

extend under the entire pit bottom, with the minimum requirement of a 300mm wide x 100mm deep rubble drain graded away from the pit for 2000mm.

Pits shall be internally sized to allow for twice the bending radius of the largest cable to be installed in the pit, plus 50%.

Conduits shall enter pits through the side and shall be fitted with bell mouths. Where practical conduits are to enter pits perpendicular to the pit wall and have bell mouths formed into the wall. Where conduits enter pits at an angle the bell mouth is to sit proud of the internal pit face. All block outs and core holes are to be sealed with a waterproof cement grout.

Pits greater than 400mm wide shall be fitted with covers and frames of cast iron and concrete. The covers shall maintain a stabilising fit with the frame by a taper contact on the sides. All vertical meeting surfaces are to be fitted to a maximum clearance of 0.25mm.

Covers and frames shall be suitable for the loading conditions.

Class	Typical use
B	Areas where there is no access by vehicles, e.g. grassed areas, gardens, etc.
C	Areas where there is access to slow moving light commercial vehicles only.
D	Areas where all vehicles can access.

Refer to *AS 3996* for details of load classifications, such as wheel loadings only. The table above shall be used for specific applications. The maximum weight of any individual section of the cover shall not exceed 50kg.

Pits 400mm wide and less shall be fitted with proprietary concrete covers. Proprietary lifting handles for all cable pit cover plates shall be supplied and mounted on suitable brackets in main switchrooms.

All pits shall be installed with the top of the cover flush with finished ground level, except in grassed areas where pits shall be 100mm above surface level with surrounding ground tapered to be flush with the top of the pit.

The minimum inside dimensions of a draw-in pit shall be 350 x 650 x 900mm deep.

19.7.4.7 Marking plates

Provide surface identification of the location of all underground electrical cables using marking plates in the following locations:

- at each cable pit
- at each change of direction

Marking plates shall be made of minimum 1mm thick brass or grade 316 stainless steel, 75 x 75mm and shall be fixed with waterproof adhesive and four brass screws.

Plates shall be engraved with arrows pointing towards the location of the cable and the words ‘Electric cable’. Marking plates shall be engraved with a minimum of 3mm-high lettering.

Install marking plates on the concrete lip of a cable pit. Do not install marking plates on cable pit lids.

Marking plates shall be installed flush with the finished ground level. In paved areas, marking plates shall be recessed or bevelled.

Concrete blocks used for installing mounting plates shall be approximately 200 x 200mm x 30mm deep.

19.7.4.8 Cable entry to buildings

Where underground cables enter a building, marking plates shall be fixed to the wall at a suitable height. Plates shall be engraved with an arrow pointing downwards and the words ‘Electric cable’.

Fix a marking plate to concrete paving or the top face of a concrete block located immediately above the cable and as close as practical to the building. Plates shall be engraved with an arrow pointing in the direction in which the cable is laid, and the words ‘Electric cable’.

Cable entry shall be designed so that there is no water ingress to the building.

19.7.4.9 Cables under roads and paths

Where a cable passes under a road or path, a marking plate shall be placed at each side of the road or path. The marking plate shall be engraved as detailed in the section above and fixed to a concrete block or to the kerb.

Reinstate road surfaces to the requirements and approval of road owners.

19.7.5 Conduits, fittings and joints

19.7.5.1 General

All conduits, fittings, installation and number of cables installed in conduits shall comply with *AS/NZS 3000* and *AS/NZS 3008.1*. Conduits shall be a minimum of 20mm, except for fire alarm systems, where 16mm diameter is acceptable.

Bends shall be of large radius. For conduits made from non-metallic materials, all fittings shall be of the same material as the conduit, and all joints shall be made with the manufacturers’ recommended adhesive cement, to be of contrasting colour to the conduit.

19.7.5.2 Affixing of conduits

All conduits shall be affixed with double-sided saddles. In corrosive atmospheres, including but not limited to any wastewater installation, saddles shall be Grade 316 stainless steel with stainless steel screws. Where a conduit run requires the use of expansion joints, use PVC saddles which allow the conduit to move.

19.7.5.3 Conduit installation

Only use uPVC conduits in areas that are not normally exposed to sunlight or other sources of ultra-violet radiation.

In coastal areas or other potentially corrosive environments, use only non-metallic conduit.

Sunlight-resistant PVC conduit and fittings shall be installed in locations where long-term exposure to sunlight or other sources of UV radiation can occur. Short runs of HD-PVC conduits from underground

submains may be surface-run where they enter an existing building, if it is not practicable to conceal them, provided they are suitably protected from mechanical damage and sunlight.

Conduits shall be installed to prevent them from transporting process materials and water to switchrooms and electrical cabinets. Termination of conduits within bund walls shall be a minimum of 100mm higher than the walls.

19.7.5.4 Expansion joints

Install expansion fittings on all straight runs of PVC plastic conduit, except those embedded in concrete or wall chases. The spacing of expansion fittings shall not be greater than 8,000mm. Install expansion couplings wherever expansion or contraction joints occur in a building slab.

19.7.5.5 Conduits in slabs on the ground

Conduits run in the sub-base under floor slabs shall be HD-PVC.

Conduits in slabs shall be securely fixed to reinforcing rods, passing either above a single layer of rods, or between a double layer of rods. Locate conduits mid-way in the thickness of the slab.

Avoid or minimise crossover of conduits within a slab. If a crossover cannot be avoided, intersection angle shall be greater than 30^0. Tie together conduits at the point of crossover.

Keep a minimum horizontal clearance of 75mm between conduits in slabs.

The minimum cover over conduits shall not be less than the conduit diameter.

Inspect all conduits prior to pouring concrete. Prior to a concrete pour, submit a slab inspection report, confirming that the conduits comply with specifications.

Supervise the concrete pour to ensure that conduits are not displaced, broken or damaged.

19.7.5.6 Draw-in points

For surface-run conduit systems, draw-in points shall be provided at suitable intervals, not exceeding 12m metres for straight runs, or the equivalent of two 90^0 bends for runs including directional changes. Where used, draw-in boxes shall be adequately sized to prevent undue deformation of the cables.

Materials used to lubricate cables whilst drawing-in to conduits shall be non-conductive, non-abrasive and non-hygroscopic.

19.7.5.7 Conduits for future use

All conduits for future use shall be provided with polypropylene draw cords. A length of cord 1000mm long shall be left securely fixed at the ends of each run. Conduits shall be capped and labelled.

19.7.5.8 Telephone conduits and cabling

Underground conduits shall be heavy-duty PVC type, coloured white, and spaced from other services, as per *AS/ACIF S009*.

19.7.6 Cable protection and support

19.7.6.1 General

This section relates to the manufacture, supply and installation of cable protection and support systems, such as cable troughs, cable trays and cable ladders. Use proprietary systems unless otherwise specified.

All ducts, trays and ladders shall be mounted horizontally, unless otherwise approved by Hunter Water.

All duct, tray and ladder covers shall be secured using either:

- Proprietary clamps manufactured from grade 316 stainless steel. Note in this specific instance there is no requirement to provide isolation between the aluminium ladder/tray/cover and the stainless clamp.
- Drilled and tapped stainless steel threaded screws.

Self-tapping or self-drilling screws are not to be used.

19.7.6.2 Ducts

Ducts shall have screw-fixed covers, unless installed in a location not readily accessible, where clip-on lids may be used. All fixing methods shall provide a smooth internal surface for the cables.

The ducts shall be adequately supported in accordance with the manufacturers' recommendations and load tables.

19.7.6.2.1 Materials

Select materials to suit the environment in which they are to be installed. Consider the material performance in environmental conditions, such as corrosive sewerage gases, ultraviolet light, water, salt spray, etc.

Galvanised materials shall not be used at inlet works or in coastal environments. Suitable materials include aluminium , 316 stainless steel, and PVC.

19.7.6.3 Cable trays and ladders

19.7.6.3.1 General

Perforated cable trays, cable ladders and all accessories shall be proprietary items from a single manufacturer whose range includes splice connections, expansion splices, covers, risers, crossovers, reducers, bends, and all other accessories used in the cable tray and ladder

Support brackets and accessories shall be manufactured from the same material as the cable tray and ladder. Cable trays and cable ladders shall have dedicated support brackets and shall not be mounted on handrails or guard rails. Principal approval is required for the use of dissimilar metals, and must include insulating barriers.

Metal cables tray and ladders shall be earthed in accordance with the following:

- 6mm2 earth straps are to be bolted across the connection join between individual ladder/tray lengths.
- Installation of an *AS/NZS 3000* compliant bonding earth wire directly connected between the switchboard/switchroom earth bar and one point along the length of the ladder/tray.

19.7.6.3.2 Perforated cable trays

Perforated cable trays shall be manufactured from aluminium.

19.7.6.3.3 Cable ladders

Cable ladders shall be manufactured from aluminium. The load rating of ladders shall be selected to suit the span between supports for the ladder and be a minimum of 12A grade.

19.7.6.3.4 Installation

Cable trays and ladders shall be installed to the manufacturers' recommendations. Adequate access shall be provided to cable trays and ladders.

The side walls of cable trays or ladders shall not be cut for the installation. Cutting brackets for holding ladders above or below is not acceptable. The ladder shall have additional supports installed to support this weakened section.

Cables or groups of cables shall be securely strapped to trays or ladders using proprietary UV resistant nylon cable ties or straps –400mm maximum for vertical runs, and at 1000mm maximum for horizontal runs.

Cables shall leave cable trays or ladders in such a manner that no cable shall be in contact with the side rails. In general, cables shall leave the tray or ladder in conduit, which shall be secured to the tray or ladder with a minimum of two anchors.

Cables shall be installed in one layer on all ladders and trays. A minimum of 20% spare capacity shall be required when the project is complete.

19.7.6.4 Fixing

Fixings shall be secure and adequately sized to suit the type, weight, size, shape, and location of the equipment being fixed. All fixings shall be stainless steel.

Use chemical anchors, in accordance with manufacturers' instructions for masonry applications.

19.7.7 Penetrations

Make all penetrations waterproof and vermin-proof by sealing with compounds that do not degrade the fire rating of the material being penetrated.

The following sealing systems are approved for use:

- grout
- Clipsal Fyre Seal Mastic

Do not use expanding foam for sealing penetrations.

Do not construct penetrations through damp courses.

20 General equipment

20.1 General

20.1.1 Durability of materials

Use UV-resistant materials where exposed to sunlight or other UV light.

20.1.2 Fixings

Use only stainless steel metric fixings and, where required, use appropriate isolation materials to prevent electrolysis. All equipment affixed to mounting plates shall be drilled and tapped using parallel threads. Screws, nuts and washers may only be used where nuts are easily accessible after assembly. Self-tapping or self-drilling screws shall not be used.

20.1.3 Mounting of equipment

Mount any equipment which needs to be operated or maintained a minimum of 300mm above the finished floor level.

20.1.4 Labelling of equipment

For general design requirements refer to Section 6.12.

All equipment shall be labelled to reflect the tag identifier of the device. Where the piece of equipment does not have a tag identifier the equipment description shall be placed on the label.

Labels within buildings shall be engraved laminated plastic or photo anodised rigid aluminium. Labels in outdoor locations shall be engraved aluminium.

All labels shall comply with the following requirements:

- except where otherwise required, be fixed adjacent to, but not on any item of equipment
- engraved lettering to be black on a white background for laminated plastic
- warning and caution labels to be white lettering on a red background
- the minimum height of lettering to be 10mm and of sufficient definition to allow easy reading. Note for telemetry and power pole labels the minimum lettering height is to be 50mm.
- securely fixed by minimum of two screws via tapped screw holes. Self-tapping screws, thread-cutting screws or other screw fixings are unacceptable

Socket outlet labels should state point of isolation including distribution board and circuit breaker numbers.

Labels are to comply with *AS 1319*.

20.2 Motors

20.2.1 General

Motors shall be of the premium high-efficiency type. They shall be a minimum of IE3 as per *IEC 60034-30*.

All motors shall be of the totally enclosed fan cooled (TEFC) type suitable for outdoor operations, i.e. IP66 or better.

Porous type drain plugs shall be fitted at either end of the motor, to suit the proposed angle of mounting.

All motors shall be bi-directional, unless specifically approved otherwise, or where required to meet noise limits.

All motors shall be suitable for VSD use, i.e. winding insulation on all motors shall be suitable for VSD use, and an insulated non-drive end bearing and shaft earthing ring shall be fitted to all motors in the size range recommended by the manufacturer.

All motor frames, including end shields, shall be cast-iron or steel. Non-metallic, aluminium or aluminium alloy frames are specifically prohibited. Frame sizes, mounting holes, shaft sizes, etc. must be in accordance with relevant Australian Standards.

Motor fans shall be constructed of cast-iron or steel, similar to the frame, and shall be suitable for rotation in either direction.

Airflow for TEFC motors shall be from the outboard end to the coupling end.

All machines shall be statically and dynamically balanced to G2.5 or better.

All motors shall be supplied with suitably rated lifting lugs or eyebolts to enable the motor to be slung and lifted.

Bolts and thread devices shall comply with ISO metric standards.

For frame size 225 and above, gland plates shall be 6mm thick brass. Gland plates shall include a 10mm brass earth stud, complete with nuts and washers.

20.2.2 Operating environments

Motors shall be suitable for operation in the environments in which they are to be installed, as specified for the equipment to which they are attached.

20.2.3 Anti-condensation heaters

Motor 18.5kW and above shall be fitted with anti-condensation heaters to keep the windings dry and to prevent condensation. They shall be suitable for single-phase supply and wired to a separate terminal box on the motor frame.

The heater terminal box shall be prominently labelled ‘Caution – Heaters are energised when motor has stopped – Isolate elsewhere’.

20.2.4 Surface treatment

Surface treatment should be applied to all motors as follows:

- casting dipped in a single-pack PVB etching primer 20 microns DFT
- complete motor applied a single coat of Alkyd resin gloss enamel in Munsell 5PB3/8 blue
- quick dry Alkyd finish 25-30 microns DFT
- pressed steel fan covers (greater than 30 kW) are to be two-pack epoxy powder coated white primer and two-pack epoxy topcoat
- final colour shall be confirmed with the Principal.

20.2.5 Noise

Noise levels are to be as per *AS 60034.9*, *AS 1081* and this STS.

20.2.6 Bearings

Bearings shall conform to specifications listed in *STS 600 - General Mechanical Requirements*.

20.2.7 Protection

20.2.7.1 Temperature detection

All motors shall be fitted with:

- a thermal protection device (thermal switch, bi-metallic, thermistor, RTD etc.). Where thermistors are fitted they shall be wired in series and the end leads brought out to terminals in a separate terminal box on the stator frame.

Motors 250kW and above shall have:

- One Pt100 type three-wire RTDs imbedded in each stator phase winding. The leads from each RTD shall be brought out to terminals in a terminal box on the stator frame.
- One RTD on each shaft bearing. The leads from each RTD shall be brought out to individual boxes or to a terminal box on the stator frame.

Temperature sensors shall be wired to a proprietary controller with trip interface to the control circuit.

20.2.7.2 Vibration detection

Motors 75kW and above shall be provided with vibration sensors on each shaft bearing. The leads from each sensor shall be brought out to a terminal box on the stator frame.

Vibration sensors shall be wired to a proprietary controller with trip interface to the control circuit.

20.2.7.3 Submersible pumps

All submersible pumps shall be fitted with:

- A thermal protection device (thermal switch, bi-metallic, thermistor, RTD etc.).

Submersible pumps 18.5kW to 75kW shall be fitted with:

- A thermal protection device (thermal switch, bi-metallic, thermistor, RTD etc.).
- Leakage sensor in the stator housing.

  Sensors shall be wired to the same proprietary controller with a trip interface to the control circuit.

Submersible pumps greater than 75kW shall be fitted with:

- Vibration monitoring.
- Analog temperature sensor (Pt100) for stator winding temperature in all phases.
- Leakage sensor in the oil housing.
- Analog temperature sensor (Pt100) for support bearing temperature monitoring.
- Leakage sensor in the junction box
- Analog temperature sensor (Pt100) for main bearing temperature monitoring

20.2.8 Terminal boxes and terminations

Terminal boxes shall be totally enclosed, sealed against air from the motor carcass and have flanged joints fitted with neoprene rubber gaskets and sufficient bolts or studs to ensure proper sealing.

All internal wiring shall be brought out to studs for connection to the external cabling.

All internal wiring, including thermistor wiring, shall be clearly and uniquely marked to indicate its function/identity. All termination points shall be clearly and uniquely marked to indicate their function/identity. The studs shall be mounted on suitable insulation material. Suitable phase barriers shall be provided between studs to protect cabling at different potential.

Terminal boxes shall be suitable for screened cable glands and for PVC/XLPE/VSD 3C+3E PVC/XLPE/VSD sheath cables, as used with VSDs.

A separate terminal box shall be provided for the thermistors and anti-condensation heaters. All entries to the terminal box shall be from the bottom.

Terminal boxes shall be capable of being mounted in any one of four positions and shall be on the right-hand side of the motor when viewed from the shaft end, unless specified otherwise.

Provision shall be made in all terminal boxes and on the motor frame for the connection of an earth wire to a designated earth terminal.

20.2.9 Insulation

Motors shall be insulated with Class H insulation, with the ambient temperature taken at 45°C. Motor temperature rise shall be no greater than Class B when running continuously at full nameplate rating. Insulation shall be of non-hygroscopic type.

The temperature rise at full rated motor load shall not exceed 75°K by resistance method, in an ambient temperature of 40ºC (Class E).

20.2.10 Motor ratings

The selected size and rating of electric motors shall consider transient conditions, including starting, braking, reversing, load and speed variations, load torque requirements and motor speed-torque characteristics.

The rating selection shall also consider any reduction in the torque curve as a result of the high-efficiency design.

The kW ratings of all motors, unless specified elsewhere, shall be in accordance with the load to be driven, plus at least 20%, and shall be sufficiently sized for the starting method employed.

Motors shall have a duty type of 'S1', as per *AS 60034.1*.

The nameplate kW shall be the maximum rating for continuous operation within the temperature rise for the nameplate rating.

20.2.11 Motors fed by variable speed drives

Motors supplied from VSDs shall be:

- Selected in accordance with the motor manufacturer's speed-load curves over the entire required speed range. This calculation shall be submitted for review prior to purchase.
- Fitted with a shaft earth ring and insulated bearing, in accordance with motor manufacturer's recommendations.
- Fitted with winding insulation meeting or exceeding the recommendations of the motor manufacturer for use with VSDs. Preference shall be given to motors which include this as standard for LV applications.
- Capable of withstanding 1.2 times the maximum rated speed continuously without sustaining damage.

20.3 Switches and outlets

20.3.1 General

Flush mounted light switches, isolating switches, and socket outlets shall be mounted in wall boxes. Mounting heights for switches shall be approximately 1.2m to the centre, unless otherwise indicated. Accessories within a designated wet environment shall be IP56.

20.3.2 Wall-mounted switches

20.3.2.1 General

Switches shall be a minimum 10A rating and comply with *AS/NZS 3133* and shall have a rotary action positive contact switch. Switches used for fluorescent loads shall be suitable.

Isolating switches shall be selected to meet the requirements of the location and function.

20.3.2.2 Installation of switches

Switches installed adjacent to door openings shall be installed on the lock side of the door. Adjacent switches shall not be connected to different phases.

20.3.3 230 V a.c. outlets

Fittings and accessories shall be of approved manufacture and rating and shall be selected to meet the requirements of the location and function.

UPS outlets shall be red in colour.

20.3.4 415V power socket outlets

415V power socket outlets shall be surface-mounted switch socket assembly with neutral conductors in all cases. The capacity of each socket outlet shall be suitable for the indicated load.

Positive phase sequence shall be indicated by phase rotation meters connected by red, white and blue leads in a clockwise direction.

20.3.5 415V outlets for equipment

Outlets which are used to supply power to equipment installed in plants, e.g. mixers, shall be de-contactors including sets of late-make/early-break control pins which will prevent starters from operating when not plugged in, or stop starters operating when unplugged.

20.3.6 ELV power socket outlet

ELV power socket outlets shall comprise two flat pins at right angles for DC, and flat parallel pins for AC.

20.3.7 Switches and outlet labelling

Switches, socket outlets and permanently connected equipment shall be uniquely labelled to provide ready identification. Identification includes where they are fed from, such as distribution board number, and circuit breaker number.

20.4 Luminaires

20.4.1 General

All lights shall be high energy efficiency LED types and include mechanical protection over the lamps.

Install a sufficient number of luminaires and in an arrangement in accordance with Australian Standards.

All luminaires shall be power factor corrected to minimum of 0.85 lagging. Incorporate lead/lag circuits or blocking inductors where indicated and/or where required by the supply authority.

20.4.2 Installation

Provide all fixings necessary for the proper installation of luminaires. Fit packing pieces of approved material where required to level the luminaires and to prevent distortion.

All light fittings shall be readily accessible and not mounted above equipment or features, e.g. drops over tanks, voids, etc., that impede access or present a high safety risk. All light fittings shall be accessible from a 2.4m platform stepladder or lower. If this is not possible, provide an alternative means of access that is either fixed in place or stored on site.

All fixings in outdoor locations shall be corrosion and weather resistant.

Clean all luminaires, accessories, equipment, and appliances that have been supplied and/or installed immediately prior to commissioning.

20.4.3 Recessed luminaires

Recessed luminaires shall be fitted with flexible cords with minimum 0.75mm^2 conductors and three-pin plugs. A plug socket shall be located within 500mm from the edge of the access aperture to allow the luminaire to be plugged in prior to fixing.

20.4.4 Post-top luminaires

Unless otherwise indicated, post-top luminaires shall:

- Be mounted on tapered columns with a hinge point to allow maintenance of light fitting.
- Consist of proprietary brand aluminium poles, suitable for base plate mounting on rag bolt assembly set in a concrete pad.
- The poles shall be adequately drained and fitted with an approved weatherproof lockable enclosure to house the control gear and fuse, in the lower section of the pole, within 1000mm of ground level.

20.4.5 Dry well sewage pumping stations

All lights below switchboard level shall be IP65 rating and shall be individually wired back to the switchboard.

21 Packaged plants

The use of package plants is subject to approval by the Principal.

Package plants that include a proprietary switchboard shall be acceptable only if they conform to the switchboard construction requirements of this STS (refer Section 16), in particular colour coding of cables.

For all packaged plants that are expected to use 35,000 kWh per year or more, provide a signal which corresponds to the instantaneous kW used. Use power meters, electronic motor protection relays or controllers for packaged plants to provide this signal.

22 Testing, Commissioning and Decommissioning

22.1 General

This section defines the minimum documentation, testing and commissioning requirements for Hunter Water Corporation and shall be read in conjunction with any project or task specific Technical Specification.

All electrical works undertaken on any Hunter Water asset must be tested in accordance with this standard, *AS/NZS 3000*, *AS/NZS 3017* and any other requirements specific to the works being undertaken.

Any works where testing has not shown compliance with this standard or other required specification will not be accepted until a repeat of the test confirms compliance.

All testing undertaken on any Hunter Water asset must be carried out by experienced and qualified personnel.

SCADA and automation system testing shall be undertaken in accordance with *STS 550*.

22.2 Site Documentation

Project documentation shall be submitted in accordance to Hunter Waters QF039 Handover to Operations procedure.

Hunter Water's Technical Specification – Testing, Commissioning and Process Proving, provides check sheets and hold points for the construction, pre-commissioning and commissioning phases of a project allowing for progressive submission of documentation.

Installation Test Plans (ITP) and associated Installation check Sheet (ITC) shall be developed specifically for the installation, for all works undertaken. ITPs and associated ITCs shall be submitted to Hunter Water for review two weeks prior to undertaking any works.

- Work as constructed documents, as per *STS 903 – Work as Constructed Information*
- Work as constructed documents, as per *STS 904 – Preparation of Electrical Engineering Drawings*
- Operations and maintenance manuals, as per *STS 906 – Operation and Maintenance Manual Requirements.*

22.2.1 Inspection Test Checklist (ITC's)

An ITC is required for all works and is task specific. A project or task may require multiple check sheets i.e. cable insulation, point to point, conduit installation etc. Each ITC shall specify the requirements to complete each task in accordance with this standard an *AS/NZS 3000* and record all the relevant information including settings and test results required to prove compliance and/or correct operation.

ITCs developed for instrumentation and control assets are to capture all setting and configurations for each device.

Records are to be clear and legible and are required to be incorporated into the Operational and Maintenance records.

Hold Points must be incorporated into ITCs where required or requested by Hunter Water. Provide a minimum of three days notification prior to undertaking a hold point. All ITCs capturing electrical testing must be signed off by a licenced Electrician.

22.2.2 Inspection Test Plan (ITP's)

An ITP shall outline all check sheets and relevant documentation required to complete the works under a standard, Contract or scope. Work can be broken up by area, process area, task, discipline, or other criteria as to make quality control more efficient or manageable. All criteria in an ITP needs to be completed and signed off before it can be closed out and submitted to HWC unless otherwise agreed prior to submission. Supporting documentation must be submitted with the ITP inclusive of all ITC documentation. Where required, an ITP must be endorsed (signed off) by the Contractor performing the works prior to presenting to HWC for review, HWC requires 5 days to review all documentation.

22.2.3 LOT Register

For complex works where multiple ITPs are required, a work LOT register is to be established which will identify all the quality documentation required for each work LOT or area to be submitted. The register will identify percentage complete and completion dates.

22.2.4 Drawings

A full set of current drawings shall be left on site at all times from the commencement of use of the switchboard for controlling equipment on Hunter Water property. Any recent changes shall be immediately marked in red pen on both sets of drawings. Unless stated otherwise all works will be issued as WAC in accordance with STS904.

22.2.5 Certificate of Compliance - Electrical Work (CCEW)

Provide a CCEW and a checklist confirming each test in Section 8 of *AS/NZS 3000* has been undertaken and completed successfully. The checklist is to be signed by the certifying officer on behalf of the electrical contractor. A CCEW is required for each work LOT where applicable.

Where the CCEW is for a switchboard:

- Supply two copies of the completed switchboard manufacturer's ITPs and a signed statement confirming the switchboard complies with the requirements of *AS/NZS 61439* in a clear plastic A4-size envelope or pocket.

Include one copy of all documents in the Operation and Maintenance Manual, as per STS 906 - Operation and Maintenance Manual Requirements.

22.3 HWC Minimum Electrical Testing Requirements

22.3.1 Switchboards and panels

As a minimum the following shall be undertaken by the switchboard builder:

- Routine verification in accordance with AS/NZ 61439. Includes the provision of documentation to support all routine verification categories.
- Performance of the following tests/checks:
    - Sheetmetal (external and internal) – ITC
    - Painting – ITC
    - Equipment installation – ITC for each cell, common ITC accepted for WPS and WWPS switchboards
    - Wiring (point to point) - ITC

22.3.1.1 FAT

A switchboard factory acceptance test (FAT) shall be conducted on all switchboards. Hunter Water is to be notified a minimum of two weeks prior to a switchboard FAT taking place.

The FAT shall be conducted by the Hunter Water representative. An example of the Hunter Water FAT documentation is available upon request. The following resources are to made available at the FAT:

- Licenced electrician to perform immediate rectification works, assist with fault finding and undertake testing as detailed within the Hunter Water FAT documentation.
- Automation Contractor to perform testing of the PLC and HMI testing as detailed within the Hunter Water integration guide.

The switchboard builder is responsible for having all documentation listed within Section 22.3.1 completed prior to the FAT date.

22.3.2 Low voltage insulation resistance level tests

Carry out insulation resistance tests out on all motors, LV cables, switchboards (e.g. MCCs, LV distribution panels etc.) and auxiliary equipment, as follows:

- The test voltage shall be applied to each conductor for one minute and the resistance recorded.
- Voltage rating of insulation testers shall be 500 V for 400/230 V LV equipment and 1000 V for 690/400 V LV Equipment.
- The minimum acceptable resistance value is to comply with the upper value stated in *AS/NZS 3000*.

22.3.3 Motor & electronic drives tests

The following checks/tests shall be undertaken as a minimum:

- Record nameplate data within Ellipse.
- Uncouple motor and check by hand that it turns freely and is free from undue noise – not required for submersible pump motors.
- Check all covers and guards are in place and packing material removed from air vents.
- Check each motor size against starting equipment.
- ‘Bump’ each motor to check direction of rotation prior to connecting load. Correct where necessary at the motor, or in the case of a VSD installation, correction of phase sequence via software is acceptable. In the case of a submersible motor, the correction shall be as close to the motor as practicable. Identify direction of rotation on the mechanical equipment if not already indicated and register in the test record. Recouple the motor.
- Operation of all alarms/trips and display in HMI and SCADA

- Correct display of all required monitoring points in HMI and SCADA
- Correct operation

Note: All rotations shall be referred to as clockwise or anti-clockwise, from the drive end of the motor.

22.3.4 Circuit tests

The following checks/tests shall be undertaken as a minimum:

- Check functionality, installation, rating and labelling of all relays, contactors, selector switches, pushbuttons.
- Inspect cable installations. Check sizes against the drawings.
- Check all wiring and cabling point-to-point against the interconnection wiring diagrams.
- Check function and logic of equipment interlocks.
- Check that all safety and field devices and auxiliary equipment are installed, connected, set and recorded for correct operation. Record settings and submit as part of ITC.
- Check tightness of cable terminations.
- Check freedom of operation of pushbuttons, limit switches, and the like.
- Check correct labelling of all cables, cable cores and termination strips.
- Energise lighting and general purpose outlet circuits one at a time. Check that each unit is in the correct circuit, in accordance with the drawings.
- Check that lamps operate and replace lamps as necessary.
- Check power outlets for voltage and correct rotation of active neutral and earth pins. Check all switches for correct function.
- Complete schedule for each distribution panel and insert within panel in storage provided.
- Carry out a night test on internal and external lighting levels to ensure lux levels are correct and realign luminaries as necessary.
- Complete all other tests as detailed in *AS/NZS 3000* and *AS/NZS 3017*.
- Care shall be taken in circuits which may contain semi-conductors to ensure they are not damaged during testing.

22.3.5 Protection tests

The following checks/tests shall be undertaken as a minimum:

- Check all circuit breakers, fuses, type and rating against the drawings.
- Variable circuit breaker settings shall be set to the settings provided by the protection design report or drawings and the setting entered shall be recorded on the ITC.
- Record all settings and submit as part of ITC.

22.3.6 Instrumentation

The following checks/tests shall be undertaken as a minimum:

- Operation of all alarms and trips and display in HMI and SCADA.
- Correct display of all required monitoring points in HMI and SCADA.
- Calibration and certification of instrumentation.
- Correct operation of instruments without nuisance signals.
- Correct configuration of device.

22.3.7 Power quality

The following list some specific checks and required testing to be undertaken:

- Operation of all alarms and trips and display in HMI and SCADA.
- Correct display of all required monitoring points in HMI and SCADA.
- Validate the autonomy time for UPS systems by performing a draw down test.

22.3.8 Power Supplies

The following list some specific checks and required testing to be undertaken:

- Operation of all required alarms and trips and display in HMI and SCADA

22.3.9 Optical Fibre & Ethernet cables

Test all optical fibres with a certified and calibrated optical fibre tester in accordance with *AS/NZS 14763-3*. Submit an optical fibre test report confirming successful results of all optical fibre testing.

Test all Ethernet cabling with a certified and calibrated tester in accordance with *AS/NZS 11801*. Submit a test report confirming successful results of all cable testing.

22.3.10 End of site testing

On completion of all checks and tests, ensure that all equipment disconnected and/or removed to enable checks and tests to be carried out has been replaced and/or reconnected. For example, verify that all links have been closed and tightened, all fuses replaced, all terminations made and tightened, components replaced and/or reconnected, and all covers and the like replaced.

22.4 Decommissioning

Remove all equipment and wiring that has been made redundant by the works.

All wiring shall be removed from between the switchboard or point of origin to the field device or equipment. The equipment in the switchboard cell shall remain.

As a minimum the following shall be executed:

- The drawing set shall be edited to reflect the current installation.
- Make good all cable tray looms and harnesses in accordance with this standard,
- Any grouting or sealing including fire rating must be reinstated,
- Remove all studs, brackets, fixings and supports made redundant,
- Underground reticulation systems can remain however, must be sealed and identified on the drawings if not already.
- Make good all restoration works associated with decommissioning.
- A new label shall be fitted to any spare enclosures that remain onsite.

23 Document control

Document Owner: Group Manager Planning and Engineering

Document Approver: Executive Manager Customer Delivery

Document review is as per the Integrated Management System Document Management Standard HW2013-421/22.002.

Version	Author	Details of change	Approval date	Approved by
2.1	R Moate	General review	September 2012	D Rayward
3.0	I Cox	Revisions to Sections 6, 11, 13-21, New Sections 7-10,12	13/01/2017	D Cleary
4.0	R Watson	General review of all sections, inclusive of formatting.	March 2019	L Backhausen
5	R Watson	General review of all sections, inclusive of formatting. Minor amendment.	March 2022	S Horvath
6	R.Watson	Consolidation of detailed design report section to provide clarity on expectations, upgrade of technical requirements, update for latest Australian standards, update to design requirements and submissions.	14/02/2024	R.Main
7	R.Watson	Minor changes to address contractor feedback.	10/04/2024	R.Main

Appendix A: Related documents

For clarity, where a standard has several parts and/or amendments and/or supplements, the reference number is for the leading part of the standard and the title notes what additional elements are included.

Reference number	Title
AS/NZS ISO 9001	Quality Management Systems – Requirements
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS/NZS 3008.1.1	Electrical Installations – Selection of cables – Cables for alternating voltages up to and including 0.6/1 kV – Typical Australian installation conditions
AS/NZS 61439.1	Low-voltage switchgear and controlgear assemblies – General rules
AS 60529	Degrees of Protection Provided by Enclosures,
AS 60079	Explosive Atmospheres
AS/CA S009	Installation Requirements for Customer Cabling
AS/NZS 1768	Lightning Protection
AS/NZS 2978	Insulating Mats for Electrical Purposes
IEC 60364-5-54	Low Voltage Electrical Installations, Part 5-54 – Electrical installations of buildings
IEC 62305	Protection Against Lightning
IEC 62305	Protection against lightning electromagnetic impulse (LEMP)
	Service and Installation Rules of New South Wales
	Ausgrid network standards
	Australian Communications Association (AS/ACIF) Technical Standards for telecommunications including, but not limited to AS/NZS 4117 Surge protective devices for telecommunication applications
AS/NZS 60950.1	Information Technology Equipment – Safety – General requirements
	Work health and safety regulations
	SafeWork Codes of Practice
AS/NZS 3017	Electrical installations – Verification guidelines
AS/NZS 3019	Electrical installations – Periodic verification
AS/NZS 3100	Approval and Test Specification – General requirements for electrical equipment
AS/NZS 60245.4	Rubber Insulated Cables – Rated voltage up to and including 450/750V – Cords and flexible cables
AS 60204 series	Safety of Machinery – Electrical equipment of machines
AS/NZS 3010	Electrical Installations – Generating sets
AS/NZS 4836	Safe Working on or Near Low-voltage Electrical Installations and Equipment
AS 4024.1	Safety of Machinery
STS 105	Security at Hunter Water Corporation Assets
STS 402	Construction of Submersible Sewage Pumping Stations
STS 405	Construction of Water Booster Pumping Stations

Reference number	Title
STS 550	General Requirements for SCADA and Automation Systems
STS 600	General Mechanical Requirements
STS 904	Preparation of Electrical Engineering Drawings
STS 906	Operation and Maintenance Manual Template