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

Standard Technical Specification for:

STS 500

GENERAL REQUIREMENTS FOR ELECTRICAL INSTALLATIONS

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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.

All work shall be performed in a tradesman-like manner to current industry standards. All electrical installation work shall be performed by licensed electrical contractors. On-site 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.

Hunter Water shall not be bound to check any documents submitted for errors, omissions or compliance with the requirements of the specification or standards.
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.

Unless otherwise stated, any expression such as 'give notice', 'submit', 'approval', or 'directed' means give notice to, submit to, approval by, or directed by a person nominated by Hunter Water.

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.

Any deviation from this STS shall be approved in writing on a case-by-case 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 Capability 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.
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.

<table>
<thead>
<tr>
<th>Term, abbreviation or expression</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACB</td>
<td>Air circuit breaker</td>
</tr>
<tr>
<td>Approval</td>
<td>Approved by Hunter Water</td>
</tr>
<tr>
<td>Approved</td>
<td>Included on a list prepared by Hunter Water of approved products and services</td>
</tr>
<tr>
<td>AHF</td>
<td>Active harmonic filter</td>
</tr>
<tr>
<td>AS</td>
<td>Australian Standard</td>
</tr>
<tr>
<td>AS/NZS</td>
<td>Australian/New Zealand Standard</td>
</tr>
<tr>
<td>BS</td>
<td>British Standard</td>
</tr>
<tr>
<td>Consumer mains</td>
<td>Supply cable from supply authority point of connection or from the low voltage terminals of a Hunter Water substation to the main switchboard</td>
</tr>
<tr>
<td>Contract manager</td>
<td>A person appointed by Hunter Water to act on behalf of the principal, as detailed in the contract</td>
</tr>
<tr>
<td>Conformal coating</td>
<td>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.</td>
</tr>
<tr>
<td>CT</td>
<td>Current transformer</td>
</tr>
<tr>
<td>Directed</td>
<td>Directed by Hunter Water</td>
</tr>
<tr>
<td>DOL</td>
<td>Direct online</td>
</tr>
<tr>
<td>ELV</td>
<td>Extra low voltage</td>
</tr>
<tr>
<td>FAT</td>
<td>Factory acceptance test</td>
</tr>
<tr>
<td>FCL</td>
<td>Fault current limiter</td>
</tr>
<tr>
<td>FLC</td>
<td>Full load current</td>
</tr>
<tr>
<td>FVC</td>
<td>Fused vacuum contactor</td>
</tr>
<tr>
<td>Term, abbreviation or expression</td>
<td>Definition</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>HD-PVC</td>
<td>Heavy duty PVC</td>
</tr>
<tr>
<td>HMI</td>
<td>Human-machine interface</td>
</tr>
<tr>
<td>IDMTL</td>
<td>Inverse definite minimum time lag</td>
</tr>
<tr>
<td>IMCC</td>
<td>Intelligent motor control centre</td>
</tr>
<tr>
<td>Indicated</td>
<td>As specified or shown in the contract documents</td>
</tr>
<tr>
<td>IP rating</td>
<td>Degree of protection as described in AS 1939</td>
</tr>
<tr>
<td>ITP</td>
<td>Inspection test plan and check sheets</td>
</tr>
<tr>
<td>LV</td>
<td>Low voltage</td>
</tr>
<tr>
<td>MCB</td>
<td>Miniature circuit breaker</td>
</tr>
<tr>
<td>MCC</td>
<td>Motor control centre</td>
</tr>
<tr>
<td>MCR</td>
<td>Maximum continuous rating</td>
</tr>
<tr>
<td>MEN</td>
<td>Multiple earthed neutral (system)</td>
</tr>
<tr>
<td>MIMS</td>
<td>Mineral insulated metal sheathed (cable)</td>
</tr>
<tr>
<td>MSB</td>
<td>Main switchboard</td>
</tr>
<tr>
<td>OHEW</td>
<td>Overhead earth wire</td>
</tr>
<tr>
<td>OPGW</td>
<td>Optical ground wire</td>
</tr>
<tr>
<td>Proprietary</td>
<td>A commercial supplier’s standard design of equipment or process</td>
</tr>
<tr>
<td>PFC</td>
<td>Power factor correction</td>
</tr>
<tr>
<td>PLC</td>
<td>Programmable logic control</td>
</tr>
<tr>
<td>PWM</td>
<td>Pulse width modulation</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinylchloride</td>
</tr>
<tr>
<td>RCP</td>
<td>Remote control panel</td>
</tr>
<tr>
<td>RTD</td>
<td>Resistive thermal device/resistance temperature detector (analog instrument)</td>
</tr>
<tr>
<td>Term, abbreviation or expression</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>SAT</td>
<td>Site acceptance test</td>
</tr>
<tr>
<td>SCA</td>
<td>Switchgear and Controlgear assembly</td>
</tr>
<tr>
<td>SCADA</td>
<td>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.</td>
</tr>
<tr>
<td>SLD</td>
<td>Single-line diagram</td>
</tr>
<tr>
<td>Spur</td>
<td>A radial section of the power distribution network</td>
</tr>
<tr>
<td>Submit</td>
<td>Submit to Hunter Water</td>
</tr>
<tr>
<td>Supply authority</td>
<td>The authority that supplies electricity to the locality of the project</td>
</tr>
<tr>
<td>Switchboard</td>
<td>A generic term used interchangeably that includes DBs, MCCs, MSBs, SCAs, 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.</td>
</tr>
<tr>
<td>TEFC</td>
<td>Totally enclosed, fan-cooled (motor)</td>
</tr>
<tr>
<td>THDi</td>
<td>Total harmonic distortion current</td>
</tr>
<tr>
<td>THDV</td>
<td>Total harmonic distortion voltage</td>
</tr>
<tr>
<td>TPI</td>
<td>Thermoplastic insulated</td>
</tr>
<tr>
<td>TPS</td>
<td>Thermoplastic sheathed</td>
</tr>
<tr>
<td>UPS</td>
<td>Uninterruptible power supply</td>
</tr>
<tr>
<td>VCB</td>
<td>Vacuum circuit breaker</td>
</tr>
<tr>
<td>VSD</td>
<td>Variable speed drive</td>
</tr>
<tr>
<td>VT</td>
<td>Voltage transformer</td>
</tr>
<tr>
<td>Term, abbreviation or expression</td>
<td>Definition</td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Wet environment</td>
<td>Any of the following:</td>
</tr>
<tr>
<td></td>
<td>• outdoor area</td>
</tr>
<tr>
<td></td>
<td>• room containing pipework which contains liquid under pressure</td>
</tr>
<tr>
<td></td>
<td>• area where equipment is located that requires wash down</td>
</tr>
<tr>
<td></td>
<td>• area below natural ground level</td>
</tr>
<tr>
<td>Witness point</td>
<td>An opportunity provided to Hunter Water to witness an event. Notice is to be provided but work is not required to stop.</td>
</tr>
<tr>
<td>WPS</td>
<td>Water pumping station</td>
</tr>
<tr>
<td>WTP</td>
<td>Water treatment plant</td>
</tr>
<tr>
<td>WWPS</td>
<td>Wastewater pumping station</td>
</tr>
<tr>
<td>WWTW</td>
<td>Wastewater treatment works</td>
</tr>
<tr>
<td>XLPE</td>
<td>Cross linked polyethylene</td>
</tr>
</tbody>
</table>
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 benchmark, all work shall be carried out 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 Testing of electrical services

Carry out all inspections and tests as required by AS/NZS 3000.

Minimum testing requirements are listed in the sections of this document and in the contract specifications.

5.5 Concrete structures

Concrete structures for electrical equipment such as plinths, transformer pads, switchroom floors shall have a continuous weld of the reinforcing around the perimeter of the structure to maximise current dispersal.

Supply and install a minimum of two (2) diagonally opposite earthing external connection points to allow the steel reinforcing to be connected to the Earthing system. The connection point shall be
clearly labelled in the field and identified on the earthing system drawings, easily removable mechanical protection of the connection point shall also be provided.

A preformed earthing conductor arrangement, such as a Dulmison Earthing Bond for Commercial Earthing Installations Type C70 or similar, shall be provided to connect the concrete structure reinforcing to the earth system.

Concrete pads/plinths that switchboards are installed on, be it outdoor or indoor, shall be equipotentially bonded to the main earth bar of the switchboard.
6 Accreditation

6.1 General

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.

6.2 High voltage installations

The design of high voltage works, shall be carried out in accordance with the Service and Installation Rules of New South Wales.

Submit copies of the supply authority’s comments on the high voltage design works proposed and a high voltage management plan a minimum of two weeks prior to ordering equipment.

Give three working days’ notice to Hunter Water of the date and time for energisation of high voltage works.

All high voltage installation works shall be carried out to the standard required by and to the satisfaction of the supply authority.
7 General submissions, approvals and notifications

7.1 Design

7.1.1 For connection to supply authority

Where required by the Service and Installation Rules of New South Wales or the supply authority, submit full details of switchboard design and installation procedures to the supply authority for examination.

The following information shall be provided:

1. Drawings detailing the following:
   - layout and single-line diagrams
   - compliance with standards
   - IP rating
   - voltage rating
   - segregation form
   - busbar current ratings, and
   - designed fault level

2. Protection grading curves which show how the sub circuits, service protection device and the supply authority fuses will discriminate (grade) with each other.

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

Where cascading is used, manufacturer’s data sheets shall be provided to verify correct equipment selection.

7.2 General

7.2.1 General switchboard design submission

Two sets of all drawings, schedules, or correspondence as applicable, shall be submitted to Hunter Water for review prior to switchboard manufacture. These documents shall be submitted not less than two weeks prior to commencing manufacture. Drawings and equipment schedules shall contain the following information:

- manufacturer’s name, address, postcode, and telephone number
- switchboard designation (e.g. main switchboard)
- designed input fault rating
- overall dimensions of the switchboard and any separate enclosures (e.g. cable termination enclosure)
- the hinge side of the door
• confirmation of external paint colour
• quantities and full details of all equipment, i.e. brand names and full catalogue number of equipment associated with each individual circuit and drive
• an overall single-line diagram and circuit diagrams of main and auxiliary circuits showing wire numbers, terminals and terminal numbers – any circuit external to the switchboard shall be shown in dashed line
• one complete general arrangement and wiring diagram for each different switchboard – typical diagrams are not acceptable
• 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 supports including materials, sizes, spacing, and fixing methods
• details of all internal segregation
• an arc flash study

Main 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:

i) verification of segregation
ii) verification of temperature-rise limits
iii) verification of dielectric properties
iv) verification of short-circuit capacity to the fault level and duration indicated
v) compliance with the requirements of Appendix ZD standard tests

Satisfactory test reports shall be considered suitable verification for tests (i), (iii), (iv) and (v), and a satisfactory switchboard manufacturer’s test report will be considered suitable for verification of test (ii).

7.2.2 Cable schedules

Cable schedules shall be produced and provided using Excel for all cables, including optical fibre, security alarm and fire systems. The file name shall be a drawing number related to the installation. Cable schedules shall have, as a minimum, the following column headings:

• cable number
• from drive/service
• to drive/service
• termination diagram drawing number
• number of cores
• core size in CSA (mm2)
• cable type, e.g. Cu XLPE/PVC
• estimated length
• comments
7.2.3 Conduit schedules

Conduit schedules shall be produced for treatment plants using Excel and each conduit schedule shall have a file name which is a drawing number related to the installation. Conduit schedules shall have, as a minimum, the following column headings:

1. conduit number
2. from pit/location
3. to pit/location
4. conduit diagram drawing number
5. conduit size
6. cables installed in conduit
7. estimated length
8. comments

7.2.4 Label schedules

A full schedule of labels is to be provided. For more information on labelling requirements, refer to 16.5.16 Labelling.

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)

7.3 Construction

7.3.1 Site documentation

A full set of current drawings with any recent changes marked shall be left on site at all times from the commencement of use of the switchboard for controlling equipment on Hunter Water property.

7.4 Commissioning

7.4.1 General

ITPs shall be developed specifically for the installation, and submitted minimum two weeks for review prior to the commencement of commissioning.
Completed ITPs shall be submitted for review and included as part of the equipment’s operations and maintenance manual.

Minimum ITP requirements for specific classes of equipment are detailed in the sections specific to that class of equipment.

### 7.4.2 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. Include these test documents in the Operation and Maintenance Manual. Submit the completed checklist to Hunter Water at least five days prior to pre-commissioning.

Where the CCEW is for a switchboard:

- Place 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.
- Affix to the metering panel or switchboard with tape.

Include one copy of all documents in the Operation and Maintenance Manual, as per [STS 906 - Operation and Maintenance Manual Requirements](#).

### 7.4.3 Low voltage insulation resistance level tests

Carry out insulation resistance tests out on all motors, LV cables, MCCs, LV distribution panels, 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 500V for LV equipment.
- Acceptable resistance minimum value is to comply with the upper value stated in *AS 3000*.

### 7.4.4 Motor tests

Carry out the following:

- Record nameplate data.
- 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 also register in the test record. Recouple the motor.

Note: All rotations shall be referred to as clockwise or anti-clockwise, from the drive end of the motor.

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7.4.5 Circuit tests

Carry out the following:

- Check functionality of all relays, contactors, selector switches, pushbuttons, installation, adjustment, rating, and labelling.
- 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 ITP.
- Check tightness of cable terminations, and 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 AS3017:2007 Electrical installations – Verification guidelines.

Particular care shall be taken in circuits which may contain semi-conductors, to ensure they are not damaged during testing.

7.4.6 Protection tests

Carry out the following:

- Check all circuit breakers, fuses, type and rating against the drawings.
- Record all settings and submit as part of ITP.

7.4.7 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.

7.5 Documentation

Commissioning of the electrical asset shall not be considered complete until the following have been delivered and reviewed:
7.6 Decommissioning

Remove all equipment and wiring that has been made redundant by the works.

Motor wiring shall be removed at the terminals in the switchboard. The equipment in the cell shall remain. A new label shall be fitted to the door, for example:

```
SPARE
Formerly: Lime dosing pump MF1234
```

The drawing set shall be edited to reflect the current installation.
8 Power distribution and overhead networks

8.1 General

Power distribution applies to HV and LV power distribution and reticulation. It may consist of overhead and/or underground infrastructure distributing power between facilities, or buildings within a facility, and includes transformers, protection, switchgear, lighting, poles, cables, lightning protection, and earthing.

Design and construction of the power systems detailed in this section shall also consider all other additional submissions, witness points, ITPs, and other requirements specified in other sections within this STS.

Underground Installations shall also comply with 20.5 – Reticulation wiring.

8.2 Submissions

The submitted detail design report shall include documented evidence of compliance to relevant standards. It shall include, but is not limited to, the following reports where relevant:

- earthing study
- protection report, including Power Tools for Windows file
- arc flash study
- insulation report
- lightning protection report
- lighting report
- overhead stringing and pole footing details
- single-line drawing detailing interlocking system
- maximum demand calculations
- trenching details
- wiring system details
- pole and assembly designs
- earth grid design
- transformer details
- schematics
- general arrangements
- equipment details
- harmonics study

8.3 ITPs

ITPs shall include checks for:
• operation of all alarms and trips and display in HMI and SCADA
• correct display of all required monitoring points in HMI and SCADA
• primary injection tests on all HV protection

8.4 Generator supply

All main switchboards shall be provided with a facility to connect a generator. Submit calculations on generator sizing.

Where a temporary generator is being supplied as part of a program of works, take into consideration total instantaneous plant power for the facility being upgraded.

8.5 Consumer mains

The maximum voltage drop in consumers’ mains at any site shall not exceed two percent (2%).

8.5.1 Pump stations

The maximum demand for pumping stations with one or two pumps installed shall be based on all pumps running simultaneously and 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, with fan if installed, plus auxiliaries.

8.6 High voltage installations

8.6.1 Redundancy

On treatment plants where two separate power supplies are available and have been approved by the supply authority, distribution of the power in the plant shall be such that either incoming power supply can supply the main switchboard if one supply is lost.

8.6.2 Point of connection

Where the power supply is being upgraded from LV to HV, the point of connection to the supply authority shall be moved to the site boundary. The previously defined supply authority easement shall be removed.

For all new HV sites, the point of connection shall be located at the site boundary.

8.6.3 High voltage protection

Power supplies for operation of HV protection systems shall be separate from all other power supplies outlined in 24VDC power supply
8.6.4 **Operation of high voltage circuit breakers and isolators**

HV circuit breakers and isolators shall be operable via a high voltage remote control panel (RCP). The RCP shall be located away from HV circuit breakers and isolators. The exact location of the RCP is to be nominated by Hunter Water.

Isolators in the same ring main unit as the HV circuit breaker and on the load side of the HV circuit breaker do not need to be remote operable. Air break switches also do not need to be remote operable.

Fault interrupters shall be remote operable.

8.6.5 **Switchyard/substation fences and gates**

The design of the system shall comply with *AS 2067*:

- The fence posts shall have a welded tab with a 13mm² hole in the centre.
- Gates shall be inward-opening.
- Fence-earthing requirements are detailed in 9.8 Earth systems for high voltage systems.
- Should isolation panels be required to eliminate the transfer of a fault voltage, the contractor shall take into consideration the materials to be used with respect to the bushfire zoning of the installation.
- Extension or connection to any switchyard fencing shall not be permitted without the authorisation of Hunter Water’s High Voltage Electrical Engineer. Approval will not be given without an earthing/ fault study being submitted, complete with mitigations of transfer voltage.

8.7 **Monitoring**

This clause applies to both high voltage and low voltage power distribution and reticulation. The monitoring shall be powered via a UPS system.

**Air circuit breakers and high voltage circuit breakers:**

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

- racked in, racked out (if rack-able) status
- open/closed status
- tripped status
- log of faults (time, fault, current, duration)
- voltage, current and power (if available)

**Air break switches and isolator switches:**

- Open/closed status

**Protection relays:**

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

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- all utilised alarm statuses
- current (RMS per phase, RMS earth value)
- volts (RMS per phase, RMS earth value)
- power (kW, kVAR, KVA) if available
Transformers:
Configure and program the local SCADA and HMI and send to Head Office SCADA, as a minimum, the following information:

- Over-temperature warnings/alarms
- Gas alarms

Power factor correction:
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

8.8 High voltage and low voltage remote control panels

The following functionality in the remote control panel:

- Provide hardwired selector switches for each circuit breaker for operation.
- Provide hardwired selector switches for each isolator switch (where remote operation for isolators is required) for operation.
- 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.
- Provide 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 the RCP is located externally, the panel and front door shall be stainless steel. Where the RCP is installed internally the RCP shall be installed with a clear polycarbonate window.

For a high voltage RCP, a panel door is not required if a permissive HV key lock is installed for the switch operation.

For a low voltage RCP, a panel door is not required if a permissive LV key lock is installed for the switch operation.

The HV RCP shall be for HV switchgear only and the LV RCP shall be for LV switchgear only.

8.9 Overhead network

Ausgrid Network Standard NS220 Overhead Design Manual shall be used as a guideline for all new installations. List all assumptions prior to design to Hunter Water for comments.

All poles shall have hardstand areas, installed from access roads to poles that are suitable for elevated work platform operation.

Warning – this document is current at time of printing or downloading. It may be reviewed and amended prior to the noted review date at the discretion of Hunter Water Corporation.
Where high voltage overhead power cables transition from bare conductor to insulated conductor, an earthing and protection study shall be performed. Surge protection and earthing of screens shall be installed as per report recommendations.

Where poles are being installed on an existing powerline, the pole shall be installed in line with the existing overhead power lines.

Where a spur is installed on a feeder, an air break switch shall be installed to provide isolation capabilities of the spur.

For 33kV distribution, an OHEW shall be installed.

Minimum span clearances shall meet AS 7000 requirements plus 0.5m calculated at 75°C.

For cable selection, refer to 20.4.6 Aerial cables.

### 8.10 Poles and assemblies

#### 8.10.1 New poles and assemblies

- Pole embedment depth shall consider site conditions.
- Supply and install as per Ausgrid Network Standard NS128 Specification for Pole Installation and Removal treated and suitably rated poles, including all cross arms, insulators and hardware for the installation.
- Poles shall be minimum 14m/8kN (Ausgrid specification) for high voltage poles.
- Poles shall be minimum 11m/6kN (Ausgrid specification) for low voltage poles.
- Areas where there is significant groundwater, such as the Tomago and Tomaree bore fields, the poles shall require installation of concrete-encased cylinders for support.
- Poles shall be uniquely labelled. Pole identification numbers shall be advised upon request.

#### 8.10.2 Modification and/or removal of existing poles and assemblies

- A pole condition assessment shall be undertaken prior to any proposed modifications.
- Modification of existing poles and assemblies do not need to comply with Ausgrid Network Standard NS220 Overhead Design Manual general arrangements, but do need to comply with clearances and minimum loading requirements.
- Where an existing pole and assembly is being modified, indicate the remaining expected life of the pole and the minimum percentage wood of the pole that is required to meet strength requirements.
- Removal of an existing pole shall comply with Ausgrid Network Standard NS128 Specification for Pole Installation and Removal.

### 8.11 OHEW

The OHEW shall:
- Be an OPGW type.
- Include minimum 60 fibre the centre of the earth wire.
- Be rated for maximum earth fault as determined by the earthing report.
- Supported by specifically designed mounting brackets, utilising existing poles where possible.
- Provide minimum 60 degrees of protection, an additional bracket and/or reconfiguration of pole assembly may be required to be performed to achieve this.
- Provide a maximum line to ground impedance of 10ohms/km. Where the OHEW is installed within 2km of a switchyard or ground-based substation, the line to ground impedance shall not exceed 5ohm/km. Impedance shall be calculated using dry summer conditions.
- Be installed so that tapings/links can be removed to isolate each section every 2km to enable testing.
- Have a coil of 20m of spare cable every 1km. The fibre optic cables shall be terminated in a specially designed stainless steel enclosure, minimum IP56. The OPGW shall be mounted on a specially designed H-bracket. The centre of the bracket shall be mounted 2.4m from the ground. The coil shall not be installed on a pole that has other switchgear installed on it.

Where a facility has a switchroom, the fibre optic requirements specified in 20.4.13 Optical fibre cables shall be applied.

Bore station transformer poles shall have a coil of 20m of spare cable. The fibre optic cables shall be capped and shall be mounted on a specially designed H-bracket. The centre of the bracket shall be mounted 2.4m from the ground.

Where feeders are run in parallel and where poles are in close proximity, the OHEWs shall not be connected together.

The droppers shall be a minimum of 70mm², insulated for an initial 1m penetration into the soil, and mechanically protected to 2.4m up the pole.

Either driven electrodes, minimum length of 5.4m and 15mm diameter copper, or core drill direct buried copper conductor, backfilled with bentonite, to an equivalent electrode depth are acceptable.

### 8.12 Interlocking

Where operation of other switchgear is required to provide safe operation of the installation, such as high voltage switching or operation of bus ties, a keyed or mechanical interlocking system shall be installed.

Integrated earth systems shall be designed to prevent closure onto a live circuit, with all external sources to be considered as part of the interlocking system.

Where an installation has an existing interlocking system, then future interlocking shall be from the same manufacturer.

Where a circuit breaker is withdrawable, the interlocking shall be fitted to the circuit breaker chassis.
9 Earthing

9.1 Submissions

The following reports shall be submitted with the concept design report:

- earthing study
- submit details showing the proposed earthing arrangement for comment

9.2 Witness points

- Welding concrete reinforcing prior to pouring.
- Connecting earth cables to concrete reinforcing.

9.3 ITPs

ITPs shall include:

- current injection test
- test earth electrodes shall be installed on all earthing systems
- Check continuity of static earthing throughout all steelwork within the installation to the main earth bar. Earth resistance testing using an approved test instrument shall be carried out in accordance with the requirements of AS/NZS 3000 before and after the installation is bonded to the grid.

9.4 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 supply authority.

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 switch room, the main earth bar shall be located in the switch room and shall be mounted above the floor level, preferably in a corner, and clearly labelled. For installations which do not have a switch room, the main earth bar shall be located in the switchboard. Switchyards and substations shall also use an earth bar to connect the earth cables.

All earth cables connected to this bar shall be uniquely identified, with the same number appearing at both ends of the cable.

All metallic stands and structures that have electrical equipment mounted on them shall be equipotential bonded to earth using an appropriately sized earth conductor.

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.
9.5 Equipment earthing

All electrical equipment and exposed metal on which electrical equipment is mounted shall be earthed in accordance with the requirements of AS/NZS 3000 and the supply authority.

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, 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.

All earthing cables shall be identified with a unique tag. Tags shall be listed on electrical drawings.

9.6 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 in order 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 the lid is flush with the ground surface or aggregate.

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.

9.7 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 3000.
- The earthing conductor shall be connected via CAD welding or ‘C’ Crimp to the reinforcing steel of the footing and/or slab and the driven electrode.
- Electrodes shall be a proprietary product and fit for purpose.
- The connection at the top of all earth electrodes shall be installed in earthing boxes. The minimum opening size for earth boxes shall be minimum 200 x 200mm, complete with screw-on lids.
- Provide all earth electrodes with an accessible removable type connection or link to enable resistance tests to be carried out.
• The main earth shall be installed and labelled as per AS/NZS 3000.

9.8 Earth systems for high voltage systems

Earth systems shall be designed, installed, and commissioned as per AS/NZS 3000, AS 2067, ENA EG-0, and ENA EG-01.

All high voltage equipment shall be connected to the main earth grid at two points located on diagonally opposite sides of the equipment by two (2) separate conductors originating from the earth grid or main earth bar.

Connections from earth grids to other structures, such as water mains, to improve performance, shall be approved by a responsible person at Hunter Water for high voltage installations. Should approval be granted, a redundant connection shall be installed. The connection shall be:

• segregated visibly, labelled and painted yellow for above ground structures
• on separate structures, if possible, if not possible to be on separate structures, then a minimum separation of 10m
• installed in a pit if structure is below ground

Minimum 70mm² bare stranded and/or PVC-covered shall be used for major equipment bonds.

All outdoor high voltage equipment with manual operating mechanisms shall be fitted with 70mm² tinned copper flexible earth braids across all hinged joints.

Where fencing is installed for a switchyard or substation, every second fence post shall be connected to the earth system.

Operator mats shall not be directly bonded to earth. The operator mat shall be bonded to the operator handle, which is in turn bonded to earth.

9.9 Functional earthing

Functional earths shall be installed for:

• communications
• instrumentation
• screens

All functional earths shall be installed to comply with the requirements of AS/NZS 3000.

9.9.1 Instrument earths

At treatment plants, all instrument earths shall be connected to an insulated earth bar located in the PLC cubicle and this earth bar shall be connected to the power earth with a 6mm² earth wire in one location only.

9.10 Earthing of variable speed drives

Refer to 15 Electronic drives.
10 Lightning protection for switchyards, substations and facilities

10.1 Submissions

Submit risk assessment, detailed design calculations and schematic diagrams to Hunter Water for review.

10.2 General

All new assets should be assessed on the need for lightning protection. This section refers to the following assets:

- substations
- switchyards
- wastewater and water pumping stations
- all treatment plant structures
- telemetry masts

The lightning protection system shall comply with AS/NZS 1768 and shall defend all buildings, structures, equipment and personnel in the premises against lightning strike.

This section is in addition to the requirements outlined in 8 Power distribution and overhead networks and 10.9 Surge protection. The lightning protection system shall include air terminations, down conductors, event counters, joints, bonds, test joints, earth terminations, and electrodes. All ancillary equipment needed for a complete working system shall be provided.

Fixing conductors to roof surfaces shall not damage roofing or weatherproof membranes. All holes made on walls, roofs or ceilings for installing lightning protection equipment shall be filled, grouted or otherwise sealed to prevent the ingress or collection of water.

10.3 Design

Carry out a lightning risk assessment in accordance with AS/NZS 1768 to determine what measures, if any, shall be needed for protecting personnel and property. Implement lightning protection measures as recommended by the assessment.

All building structures and equipment in the premises shall be protected against lightning strikes in all directions from vertical to 15 degrees from vertical.

Conductors shall be so sized to ensure a low resistance path for lightning discharges, in compliance with applicable regulations and standards.

10.4 Air terminal grid

An air terminal grid shall comprise vertical lightning rods, finials and/or spheres, and an interconnecting network of high-conductivity copper tape. All metallic projections and metallic equipment on building roofs and other structures shall be bonded to form part of the air termination network.
Proprietary air terminal bases shall be provided for vertical lightning rods and finials. If free-standing towers are provided for air terminals, they shall be structurally designed for appropriate loadings.

Interconnecting copper tape shall be appropriately sized to carry the anticipated lightning current, but shall not be less than 3 x 25mm in cross section in any case. All tapes shall be rigidly held by suitable saddles at 600mm minimum intervals for horizontal runs, 1000mm for vertical runs, and shall be effectively bonded at junctions. The tape shall be supplied in continuous unbroken lengths. Jointing shall be avoided in straight runs as far as practicable.

10.5 Earth conductors

All down conductors from the air terminal network to the earthing electrodes shall be of appropriately sized PVC-insulated copper tapes, subject to a minimum cross-section of 3 x 25mm, run on clamps fixed to the surface of the building/structure at intervals not exceeding 1000 mm. The down conductors shall, as far as practicable, be unobtrusive and the colour of the PVC sheath shall match the colour of the building finish.

Bonding to air terminations shall be by exothermic chemical bonding. Down conductors shall follow the shortest possible route, vertically, along the building exterior to the nearest earthing electrode.

10.6 Down conductors

Down conductors shall:

- Be distributed around the outside walls of the ‘protected’ structure.
- Be installed at each corner of the structure with additional down conductors installed at spacing not exceeding twenty (20) metres.
- Follow the most direct path possible between the air terminal and the earth. A maximum of 45 degree bends may be used in installation.
- Be located away from areas where personnel are likely to congregate.
- Avoid crossing other electrical services or pipework.
- Be positioned as near as possible to the exposed outer vertical corner of the structure.

10.7 Joints and connections

The number of joints on the lightning protective system shall be kept to a minimum. Joints shall be made in visible and accessible positions. Joints shall be electrically and mechanically effective. For overlapping joints, the length of overlap shall not be less than 25 millimetres. Exothermal chemical bonds shall be used for all joints except testing joints. Four bolt tape clamps shall be used for bolted joints, and all contact surfaces shall be smooth and tinned.

No dissimilar metals shall be jointed without the written recommendations of the lightning protection system manufacturer. Where dissimilar metals are to be bonded together, purpose designed proprietary brand of bimetallic connectors shall be used and moisture shall be kept away from the joints. Conductors and joints that are exposed to corrosion shall be protected by the application of approved anticorrosive paint.
A testing joint shall be provided between each down conductor and its associated earth electrode. The positioning of the test joints shall be convenient for testing purposes, but shall not obstruct other services or impair the architectural features of the building. All test joints shall be protected from mechanical damage by heavy-duty non-metallic casings. The casings shall be suitably painted to match adjacent wall finishes and shall be unobtrusive when installed.

10.8 Earth electrodes and pits

Earthing electrodes shall be steel-cored copper or stainless steel rods, not less than 15mm in diameter. The rods shall be extensible in standard multiples with screw and socket joints. Each earth electrode shall be driven to a minimum depth of 5 metres into the ground. Where interconnecting conductors are to be buried in the ground, the minimum burial depth shall be 500mm below finished ground level.

Lightning earth rod design shall be based on soil resistivity tests. Where an electrode cannot be driven, it shall be installed to a bored hole and backfilled using a suitable agent which helps to retain moisture and enhance soil resistivity.

A sufficient number of earthing terminations shall be provided for compliance with AS/NZS 1768 and applicable codes of practice. The resistance of each complete earth termination, measured separately, shall be less than 10 ohms. Where this is not possible with one earth electrode, the design shall be reviewed and modified to reduce the earth impedance.

10.9 Surge protection

10.9.1 Low voltage mains protections

Shall:

- Be shunt surge diverters.
- Have fault contact wired to PLC to monitor condition of surge diverters.
- Have a discharge current (8/20µs) of 50kA or greater.
- Use a minimum of 4mm2 and installed in accordance with AS 4070.

10.9.2 High voltage surge protections

Surge protection shall be installed on:

- pad mount and pole mount distribution transformers as close as practical to the primary bushings
- underground to overhead connection poles
- as per overhead power lines lightning design

HV surge arresters installed on pole mount transformers shall be installed on each high voltage phase in accordance with a general arrangement drawing. A shroud shall be placed over each surge arrester to eliminate interference from birds or animals.
10.9.3 Control device protections

Shall:

- Be series surge protectors.
- Be required at both the MCC and the LCP
- Have a minimum discharge current (8/20µs) of 5kA or greater.
- Comply with AS/NZS 1768.

10.9.4 Instrument signal protections

Shall:

- Be series gas discharge surge protectors.
- Be required at both the MCC and the LCP
- Have a minimum discharge current (8/20µs) of 5kA or greater.
- Comply with AS/NZS 1768.

10.9.5 Radio antenna protections

Shall:

- Be series surge protectors.
- Have a minimum discharge current (8/20µs) of 20kA or greater.
- Comply with AS/NZS 1768.
11 Power quality

11.1 Submissions

The following reports shall be submitted with the concept and detailed design report:

- THDV calculations
- THDi calculations
- Power factor calculations

11.2 ITPs

ITPs shall include:

- Operation of all alarms and trips and display in HMI and SCADA
- Correct display of all required monitoring points in HMI and SCADA
- Measurement of THDv for a period of 24 hours
- Measurement of power factor for a period of
- Hold up period for UPS

11.3 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 supply authority’s negotiated connection offer, whichever is lower, at the supply authority’s point of connection or a Hunter Water facility’s substation transformer secondary terminals.

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 capacity.

11.4 Power factor correction (PFC)

PFC equipment shall:

- Be designed to achieve a power factor of 0.95 lagging.
- Be installed in a separate enclosure – if an enclosure is within a switch room, it shall be physically separated from the 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 for low voltage installations. Anti-Harmonic reactors shall have Class F insulation. They shall be rated to at least 1.25 times the rated capacitor current and designed to carry 1.5 times the rated capacitor current without saturating. Each step shall be 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.
- Be totally isolated by the PFC main switch.
- Disconnect automatically 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 and disconnect the power factor correction system.

11.5 UPS equipment

11.5.1 General

A filtered and surge-protected uninterruptible power supply (UPS) unit shall be used for supply to the associated PLC controls, SCADA and control networks and instrumentation when required.

The UPS shall include surge protection on both input and output circuits.

11.5.2 Capacity

The UPS shall energise and continuously supply all the connected equipment.

Size the UPS for the load imposed by all connected equipment plus 30% additional capacity.

Include sufficient battery capacity to provide at least four (4) hours operation without supply from the mains, at full rated load.

11.5.3 Performance

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

- output voltage: 230Vac ±5%
- total harmonic distortion: 5%
- output frequency: 50Hz ±1 Hz
- maximum rate of frequency drift: 0.1Hz/second
- overload capacity: 120% for 10 minutes
- audible noise: <60dB(A) as per AS 2107

11.5.4 Alarms

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

- unit failure
- general
- battery low
- buffering

11.5.5 Batteries

In addition to the requirements of 12.3 Batteries and chargers, the following shall apply.

Batteries shall be sealed NiCad, NiMH or sealed lead/acid recombination type.

Batteries shall be housed in a separate enclosure that matches the UPS enclosure in appearance. Easy access shall be provided for maintenance and removal. The enclosure must be installed within an adequate bund to deal with possible leakage. Design consideration for heat and gas discharge must be demonstrated.

11.5.6 Bypass

The UPS shall be cabled and a switch shall be designed and installed 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. The circuits normally supplied by the UPS shall be then connected to mains power. The neutral conductor shall be continuous and not be switched by the bypass.

UPS bypass shall be monitored and displayed by SCADA.

11.5.7 UPS location and enclosure

The UPS enclosure shall be IP42-rated for units located in switch rooms.

The UPS installed in outdoor switchboards or equipment shall be rated for 50°C.

Provide ventilation fans as necessary for reliable operation of equipment within the enclosure. Ventilation inlets are to be fitted with filters to prevent the ingress of dust.

Special consideration shall be given to batteries and UPS mounted in outdoor switchboards, e.g., automatic inlet valves. Adequate shade and/or ventilation shall be provided to meet the manufacturer’s specifications.

UPS equipment shall be minimum IP2x when located within a switchboard.

11.5.8 UPS power distribution

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

This distribution board shall have a main switch handle on the outside of the enclosure to isolate the supply in case of an emergency. This switch handle shall not prevent opening of the distribution board door. The distribution board shall be located adjacent to the supply circuit breaker for the UPS.

The distribution board shall have a metal escutcheon which prevents access to live parts when operating circuit breakers.
11.5.9 Power supply to the UPS

UPS input power shall be supplied from a distribution board downstream of a main switchboard using 6kA circuit breakers. Where this is not practical, provide evidence that the UPS input fault withstand capability is greater than the let-through energy of the circuit breaker feeding the UPS.
12 DC power supplies

12.1 ITPs

ITPs shall include:

- operation of all required alarms and trips and display in HMI and SCADA
- factory ITP covering all off-site activities, e.g. engineering, design, supply, manufacture, factory assembly, factory acceptance testing, type testing, resolution of factory defects/punch lists, release for delivery, preparation for transport, etc.

12.2 General

Install separate power supply systems for motor control circuits, PLC input/output circuits and high voltage protection. Do not interconnect these separate power supplies.

24V DC power supplies shall:

- Be sized to provide for the full load within the switchboard, plus a minimum of 20% spare 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 and be connected to the PLC as an alarm.
- Be connected to one set of active and 0V links. Except where the power supply is for high voltage protection, the 0V link shall be directly connected to earth.
- Provide sufficient ventilation to prevent the power supplies from overheating. Where dual redundant power supplies are installed, mount power supplies to allow for one power supply to be removed while the other is still operational.

Unless otherwise stated, PLC input/output circuits and instrumentation loops shall be supplied by dual power supply units with a common redundancy module installed to prevent any back feeds to either power supply in the event of an internal fault.

Separate distribution for PLC input/output circuits consisting of the isolators, fuses and links shall be provided in each separate PLC/instrumentation cubicle.

12.3 Batteries and chargers

12.3.1 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 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 ten (10) hours back-up power at full rated load.

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

- input voltage rating: 230V – 10%, 50Hz – 5%
- communication (HV only): industrial Ethernet, Modbus TCP and/or Modbus
- enclosure rating: IP41 (minimum)
- cable entry: bottom, side

12.3.2 Design

Battery chargers

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

Batteries and chargers shall be housed in one (1) cubicle where practical, and the construction of the cubicle shall provide separate compartments for electrical equipment and batteries.

The following facilities shall be provided:

- AC input - 230V, 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 AC voltage spikes
- under-voltage charging
- over-voltage
- short-circuit of output
- earth fault
- automatic current limit of output current
- hazard signage

Battery systems

Warning – this document is current at time of printing or downloading. It may be reviewed and amended prior to the noted review date at the discretion of Hunter Water Corporation.
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 (3) times in succession, without the final voltage being less than 80% of rated voltage.
The batteries shall have a design life of five (5) years and shall have a rating of 24VDC nominal voltage.
All battery cells and cases shall be identical.
Bolted solid link connections shall be provided between all cells on the same tier. Two (2) 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.

12.3.3 Installation

All battery banks and charger systems are to be free-standing. The distribution board is to be wall-mounted.
13 Low voltage switchgear

13.1 Submissions

The following reports shall be submitted with the design reports:

- schematics and general arrangements
- any deviation requests from arrangements in this standard

13.2 ITPs

ITPs shall include:

- operation of all alarms and trips and display in HMI and SCADA
- correct display of all required monitoring points in HMI and SCADA
- correct operation

13.3 Circuit breakers

13.3.1 General

All circuit breakers shall:

- Have a fault breaking capacity suitable for the fault rating of the installation. This may include cascading combinations.
- 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.
- Lock the cubicle door 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
- Display clearly the manufacturer’s circuit breaker nameplate even when circuit breaker accessories are fitted.

13.3.2 Miniature circuit breakers

Miniature circuit breakers (MCB) shall have a minimum fault breaking capacity of 6kA and shall have fault current limiting devices installed upstream if required to limit the fault level

13.3.3 Moulded case circuit breakers

Moulded case circuit breakers shall:

- Be electronic with adjustable thermal and magnetic pickup and time delays.
- 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.

### 13.3.4 Air circuit breakers

Air circuit breakers (ACB) shall:
- Have electronic protection incorporated with adjustable instantaneous, thermal, magnetic settings and time delays.
- Be mounted in a segregated cubicle and be draw-out type with padlocking facilities for locking in the open and withdrawn position. For mechanical interlocking use a fortress key.
- Be used as main switches on all switchboards with ratings 800A and above.
- Be operable via a low voltage RCP.
- The racking handle shall be stowed within the ACB when not in use.

### 13.3.5 Residual current circuit breakers

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

### 13.4 Fuses

Fuses shall:
- Be suitable for the fault level of the installation and shall discriminate properly with other protective equipment. Let-through energy and peak current cut-off is to suit the protected equipment.

### 13.5 Low voltage isolation switches

Isolation switches shall:
- Comply with AS/NZS IEC 60947.3.
- Be suitable for fault-making/load-breaking duties.
- Have provision for the attachment of padlocks for isolation when the switch is in the ‘Open’ position. It shall not be possible to open the cubicle door whilst the switch is in any position other than ‘Open’.
- 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.

### 13.6 Generator changeover switches

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

Comply with AS/NZS IEC 60947.2 and as per preferred equipment list.

Coil voltages shall be 24V DC except for contactors coil consumption above 150W (pickup). These shall be interfaced with a relay to control a 240V AC coil.

13.8 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.

13.8.1 Motors 22 kW and below

Install overloads with a tripping class of 10 or 10A, auto/manual reset, trip indicator and separate N/O and N/C contacts.

13.8.2 Motors above 22 kW

Install electronic overload devices which feature adjustable tripping curves, thermistor input, phase loss, asymmetry protection and power measurement and connect to SCADA.

Additional mechanical protection devices e.g. vibration sensors, seal fail devices etc. shall also be included.
14 High voltage indoor switchgear and equipment

14.1 ITP

HV switchboards shall be tested for partial discharge at factory acceptance tests and site acceptance tests. Max of 10% per tier shall be achieved.

14.2 General

ELV control for switchgear

As a minimum, the ELV compartment door of each switchgear tier shall be fitted with the following control equipment:

- digital protection relays incorporating HMIs – refer to 18.6.2 Digital protection relays for details
- pilot lights indicating status – ‘Opened’ and ‘Closed’
- pilot lights indicating ‘Protection trip’
- Local-Remote control selector switch.

‘Trip’ and ‘Closed’/ ‘Start’ and ‘Stop’ functions shall be able to be performed remotely using two (2) different methods. Separate terminals are to be provided for each method. These are:

- hardwired from a remote control panel external to the building housing the switchgear
- via an external PLC

Protection relay test blocks

Test blocks shall be provided to allow CT secondary windings to be shorted, secondary metering equipment to be disconnected from the CTs, and for a test instrument to be inserted in series into the secondary metering circuit, all while the main circuit is energised and on load. VT secondaries shall also be connected via test blocks for secondary injection testing. A spare protection relay contact programmed for trip shall also be wired to test block, as this will aid in injection testing of relays.

14.3 Vacuum circuit breakers (VCB)

Circuit breakers shall be designed in accordance with AS 62271.100.

Each switchgear unit or combination shall be capable of making, carrying and breaking the circuit load current or switch rated current, whichever is the greater. The switchgear shall also be capable of making, carrying for the specified time and breaking full prospective fault currents corresponding to the nominated symmetrical fault level of the system.

Each switchgear unit shall be arranged such that it is able to be maintained without interfering with power supply to other switchgear units forming part of the switchboard.

Switchgear shall be metal-enclosed. Isolation shall be by either withdrawable circuit breakers or fault make, load breaker switches, or bus disconnectors.
The switching device shall open simultaneously three poles of a three-phase, 50Hz circuit with rated voltage between phases equal to the nominated system voltage. The temperature rise of switching devices of any voltage shall be subject to the limitation of Table 3 of AS/NZS 2650. Temperature rises shall be maintained within the specified limits with the switching device mounted within the switchboard enclosure.

The breaking current rating shall be as specified in AS/NSZ 60265.1. The prospective symmetrical fault levels applicable shall be calculated by the contractor. The switching device shall withstand the forces due to maximum fault.

VCB mechanisms shall be stable and not operate due to vibrations or impact.

VCB mechanisms shall be designed to prevent ‘slow open’ or ‘slow close’ while in normal service, due to failure to latch correctly or for any other reason.

Closing

Switchgear closing shall be available by both of the following means:

- **Manually-charged spring** with manual and electrical release. The spring shall be capable of being left in the charged position for an indefinite period when it has been recharged after a closing operation.

- **Electrically-charged spring** with manual and electrical release. The spring shall be automatically charged following initial connection of supply voltage and shall recharge following a closing operation of the switching device and capable of being left in the charged position for an indefinite period.

Electrically wound, spring-operated circuit breakers are preferred.

VCB mechanisms shall be designed in such a manner that no damage will be caused to any part of the VCB if, while charged, the closing spring is released when the VCB is already closed.

VCB mechanisms shall be designed to prevent reclosing against a collapsed mechanism.

The design of the control system shall incorporate an anti-close and an anti-pump relay.

Tripping

Tripping shall be possible by both manual and electric trip methods.

A mechanical tripping method shall be provided for maintenance purposes.

Remote operation shall not affect the integrity of the protective device tripping circuits.

All VCBs shall have mechanical latching with electrical and mechanical tripping and shall automatically open if a reduction in vacuum occurs. Local and remote indication shall be provided to confirm such an event. The operating mechanism shall be trip-free and include an anti-pumping device.

Each VCB trip coil shall be equipped with trip circuit supervision, as per ANSI 74TC.
Operating voltages

All switching devices shall be able to meet their rated making duty for closing circuit voltages from eighty (80%) to one hundred and twenty percent (120%) of nominal and their rated breaking capacity for the trip circuit voltages from fifty (50%) to one hundred and twenty percent (120%) of nominal.

Switchgear auxiliary switches and indications

Sufficient auxiliary switches shall be provided to meet the control circuit and monitoring circuit requirements and three (3) spare contacts of each type.

A mechanical ‘Open-Closed’ or ‘On-Off’ indicator shall be provided that is directly driven by the operating mechanism to avoid incorrect indication in the event of linkage failure.

Mechanical interlocking shall be provided between different components of the equipment for reasons of safety and for convenience of operation in accordance with AS 62271-200.

A mechanical operations counter shall be provided to monitor the main switching unit.

Withdrawable VCBs

VCBs racking shall include the following positions, while the breaker remains in its cradle within the switchboard enclosure. Padlocking facilities shall be provided for each position:

‘Service’ in which both the main and secondary circuits are connected
‘Test’ in which the main circuit is isolated, but with secondary circuits connected, and
‘Isolated’ in which both the main and secondary circuits are isolated.

The racking mechanism shall be manually operated from outside the enclosure and shall be mechanically interlocked to prevent inadvertent operation. The carriage position shall be mechanically indicated.

All VCB trucks shall be earthed via spring-loaded sliding connection or a plug and socket connection, such that the earth connection makes before and breaks after the main circuit connections.

14.4 Fused vacuum contactors (FVC)

High voltage fused vacuum contactors shall be designed in accordance with AS 60470.

Control supply for FVC units shall be provided with an external power source facility for testing purposes.

The rating selected for a contactor shall be on the basis of uninterrupted duty.

All FVCs shall be of withdrawable construction.

FVCs, racking shall include the following positions, while the FVC remains in its cradle within the switchboard enclosure. Padlocking facilities shall be provided for each position:

‘Service’ in which both the main and secondary circuits are connected
‘Test’ in which the main circuit is isolated, but with secondary circuits connected, and
‘Isolated’ in which both the main and secondary circuits are isolated.
The racking mechanism shall be manually operated from outside the enclosure and shall be mechanically interlocked to prevent inadvertent operation. The carriage position shall be mechanically indicated.

All FVC trucks shall be earthed via spring-loaded sliding connection or a plug and socket connection such that the earth connection makes before and breaks after the main circuit connections.

Closing

Vacuum contactors shall be of electromagnetic operation and shall be electrically held, unless otherwise specified for the site.

Tripping

Tripping shall open the contactor when supply to the holding coil is interrupted.

Striker pin operation

Where HV fuses are used in conjunction with vacuum contactors, the fuses shall incorporate striker pins. When activated, the striker pin shall operate a latching switch with minimum two N/C and two N/O contacts. The N/O contact will trip the contactor if direct mechanical operation is impossible. The other N/O contact and one N/C contact will be used for remote indication purposes.

LV control

In addition, the LV compartment door of each tier shall be fitted with the following control equipment:

- ‘Start’ and ‘Stop’ pushbuttons

14.5 Gas insulated switchgear

For gas insulated fixed switchgear separate sealed chambers shall be provided for main busbars and circuit breakers. The switchboard bus and subsystems shall be able to provide the rated insulation level with the insulating gas at atmospheric pressure. Visual gas pressure monitoring for each sealed chamber with a low pressure voltage free contact for remote monitoring shall be provided.

14.6 Earthing switches

Earthing switches shall be manually operable from outside the equipment enclosure and provided with mechanical position indicators visible at the point of operation. The speed of operation of the earth switch contacts shall be independent of the rate of movement of the operating handle.

All earth switches shall have provision for padlocking the switch in the open and closed positions.

14.7 Voltage transformers (VT)

Voltage transformers shall be designed in accordance with AS 60044.2 and shall have phase-to-phase secondary terminals of 110V.

VTs shall be of the withdrawable type with HV fuse and LV miniature circuit breaker mounted on the withdrawable carriage. Auxiliary contacts from the LV MCB shall be wired to the LV compartment/cable box.
Operation to withdraw the voltage transformer and locking of any isolation shutters shall be possible by the operator from floor level.

VT secondary wiring shall be the same colour as the respective primary phase conductors.

Partial discharge tests shall be performed on every VT and results recorded.

### 14.8 Current transformers (CT)

CTs shall comply with AS 600044.1 and be designed with insulation and fault level ratings compatible with the switchgear.

CTs shall be mounted within the confines of the switchboard, i.e. it is not necessary to mount CTs in the cable basement below the switchboard.

CTs shall preferably not be mounted in spaces containing the insulating gas, other than air.

CT secondary wiring shall be the same colour as the respective primary phase conductors.

Toroid CT secondary wiring shall be S1-Orange and S2-Black.

CT rating plate details shall be duplicated on the outside of the circuit chamber housing the CT.

All CT tapings shall be wired to slide test link terminals in the LV compartment/cable box of the switchgear.

A magnetisation curve shall be obtained from the manufacturer for each CT in order to:

- Detect damage in transit or installation.
- Prove that the correct cores have been wired out to the relevant terminals.

The DC resistance of each CT secondary winding shall be measured and also, where possible, the DC resistance of the transformers and connecting leads recorded separately.

The insulation resistance of all secondary circuits shall be measured at 1000V DC and recorded.

Primary current injection tests shall be conducted on all CTs using adequate primary current to prove correct ratio, polarity and for differential protection schemes, to prove the correct relative polarities of all CTs of each scheme.

Partial discharge tests shall be performed on every CT and results recorded.

Records of all such tests by the CT manufacturer shall be collated by the contractor for review during the auxiliary transformer factory acceptance tests. Refer to 16.8.4.2 Routine (factory) testing for more information.
15 Electronic drives

15.1 Submissions

The following reports shall be submitted:

- schematics and general arrangements
- heat load calculations of ventilation systems
- THDV calculations
- THDi calculations

15.2 ITPs

ITPs shall include:

- Operation of all alarms and trips and display in HMI and SCADA
- Correct display of all required monitoring points in HMI and SCADA
- Correct operation
- THDV measurements
- THDi measurements

15.3 General

All electronic drives shall be installed with a line contactor in series. The line contactor shall be controlled by the electronic starter when the drive is required to run, and open at all other times.

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 required to operate a drive, e.g. line chokes and EMC filters, shall be mounted in the same enclosure. Drive equipment weighing more than six kilograms installed within a switchboard shall be mounted on welded studs. Submit a verified procedure as required for safe removal of drive equipment from the switchboard.

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. The plinth shall be hot dipped galvanised after fabrication to a minimum thickness of 85 micrometres and shall not be painted.

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

15.4.1 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 take into account the effect of any additional heat sources in the area.

15.4.2 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 effected 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.

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
- noise emissions limited to a maximum of 65 dBA, measured at one metre from the external outlet

15.5 Variable speed drives

15.5.1 Minimum specification

The VSDs shall incorporate:

- Modbus TCP/IP Ethernet connection
- external HMI

VSDs shall be rated to deliver the following at relevant ambient temperatures as defined in 16.4.1 General:

- motor FLC continuously
- 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)
- minimum of 12 starts per hour
15.5.2 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 given 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, which requires written authorisation 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 24V DC 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.

15.5.3 Switch room installations

When installed in a switch room/pump-house or any housed environment, 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. 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 mounted on the wall on a fabricated Unistrut-type mounting bracket, or be floor-standing. All wall-mounted drives shall be rated at IP54 as a minimum. Care should be taken to ensure the wall is capable of withstanding the total weight of the VSDs, along with any additional equipment.

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

All wall/floor mounted VSDs shall be bottom-connected using cable tray with adequate mechanical cable protection.

15.5.4 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 22 kW and above shall include motor thermistor inputs as a minimum. Additional RTDs may be utilised on large motors which shall also be directly connected to the VSD. The VSD shall be capable of providing alarm and trip functions for these devices.
15.5.5 Line chokes/DC bus chokes

All VSDs shall be fitted with either a line choke or DC 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.

15.5.6 Motor chokes

Motor chokes may be required when VSDs are used with long motor cable lengths. Consult the VSD manufacturer's manual and install as per its requirements. 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.

15.5.7 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.
- Unless otherwise specified, only braided, screened motor cables shall be used for all motors controlled via a VSD. The cables’ screen shall be earthed at both ends using Hunter Water approved EMC cable glands at the motor terminal box, and/or other approved means at the VSD end.
- Where the motor cables are joined in a link box or local control isolator, the cable screen should be continuous back to the VSD. This may be achieved either by using EMC glands on a common gland plate or suitable stainless steel saddles installed over the screen and screwed to a suitable top-hat bracket.

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).

15.5.8 VSD communications

Provide a Modbus TCP/IP Ethernet 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 Cat 5e SF/UTP patch leads with RJ45 metallised connectors. Factory-made leads shall be used and green in colour.

15.6 Soft starters

All soft starters are to be configured to run in bypass after 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 Submissions

The following reports shall be submitted with the design:

- general arrangements drawings
- schematics
- confirming busbar type testing certificates
- arc flash study
- protection grading study
- bill of materials

16.2 Factory inspection and acceptance testing

16.2.1 General

Make available all labour, materials, testing equipment and the like required for inspections and testing.

Give at least five working days’ notice to Hunter Water in writing of all inspections and tests.

16.2.2 Inspection

Provide an opportunity for Hunter Water to inspect switchboards during manufacture and prior to delivery to the site, in accordance with the following schedules:

MCCs

- First inspection: metalwork finished and painted and busbars installed
- Second inspection: layout of equipment prior to fixing
- Third inspection: equipment and power cables installed
- Final inspection: functional checks

MCC support frames

- First inspection: after all fabrication, welding and cleaning has been completed
- Final inspection: after application of protective coating

16.2.3 Factory acceptance testing

For all electrical control and instrumentation equipment, perform the tests detailed below, together with any additional tests, as required by the specifications.

Ensure before having carried out any tests that all equipment likely to be damaged by such tests has been removed from the circuit under test or has been isolated and earthed. Other checks and/or tests of such equipment shall be carried out to ensure it operates as required.

Carry out the following tests to prove the proper operation of the switchboard prior to despatch from the factory.

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(a) Insulation tests, using a 1,000V insulation tester, of all cables and equipment. Such tests shall include the following:
   - each phase and neutral to earth
   - each phase to neutral
   - between phases
(b) Insulation tests at 2,000V AC for one minute of the main busbars and all secondary wiring including internal wiring of instruments, control equipment, excluding electronic control equipment. Such tests shall include the following (leakage current not to exceed 10mA):
   - each phase and neutral to earth
   - each phase to neutral
   - between phases
(c) Repeat insulation tests in (a) above and report any change in insulation.
(d) Checks and/or tests to verify correct polarity, phase rotation together with fuse link ratings and the setting of overloads and protection equipment.
(e) Operation checks and tests on instruments, selector switches, module door interlocks, push to test indicators and the like, to verify compliance with Australian Standards, the specifications, drawings, and the supply authority.
(f) Secondary injection tests on all protection equipment relays.
(g) Test functionality of PLC inputs and outputs and the simulation of outputs by means of the force function in the PLC to test drive circuitry.
(h) Complete circuit component, continuity and termination checks against all relevant drawings.

Mark up drawings so that errors are corrected, omissions and modifications added. Redraw and submit all such drawings.

Should the equipment fail under these tests, the costs of replacement, repairs and any further testing shall be borne by the contractor.

On completion of all checks and tests, ensure that all equipment is disconnected and/or removed to enable such checks and tests to be carried out has been replaced and/or reconnected. For example, verify that all links have been closed and tightened, components replaced and/or reconnected, and all covers and the like replaced.

16.3 ITPs

ITPs shall include:
   - operation of all alarms and trips and display in HMI and SCADA
   - correct display of all required monitoring points in HMI and SCADA
   - resistance tests
   - labels
   - operation of switchgear
preferred products used

16.4 Design

16.4.1 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

Switchboards that are to be connected to the supply authority’s system shall have generator changeover switches and generator connection points that can be safely accessed when the switchboard is live.

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 24V DC supply.

All LV wiring within in enclosure shall be able to be isolated from one point of supply. Each enclosure shall contain wiring which is isolated from one point of supply.

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

PLC cubicles shall have a double 230V 10A socket outlet inside the cubicle. This shall supplied from the UPS for treatment plant switchboards and shall be coloured red.

Light and power distribution boards shall be standalone propriety units and not part of an MCC.

Equipment requiring regular access shall be installed between 300 and 1800mm of the finished floor level.

16.4.2 Arc flash mitigation

Switchboards shall be designed so that heated gases and subsequent pressure wave shall be directed away from persons in front of the switchboard when its doors are closed. An arc flash study shall determine the maximum impact of such an event in the immediate vicinity of the blast.

16.4.3 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 and 20 Cables and wiring

• 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

• 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

• the only devices that may be installed on the MCC cell door are the ‘Test – Off – Auto’ switch, VSD, HMI and the main circuit breaker handle

• drive status, motor running and motor currents are to be displayed on an HMI installed on the PLC cabinet door

• 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 station when selected to ‘Test’ on the cell door

Drawing samples for motor control circuits are available from Hunter Water upon request.

16.4.4 Indoor switchboards

16.4.4.1 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:

• main distribution switchboards

• MCCs

• PLC cubicles

• indoor distribution boards

16.4.4.2 Main switchboards and motor control centre requirements

Main switchboards and MCCs shall be cubicle-type constructed to the relevant parts of AS/NZS 61439, including:

• degree of segregation: Form 4a

• degree of protection: IP42 minimum

• 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
• switchboards with cable zones shall have a minimum of 400mm wide cable zones
• each tier shall have one cable zone

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 discriminate (grade) with the upstream protective device.

The design shall include a 20% of spare cells across all cubicle sizes to allow for future expansions.

### 16.4.4.3 PLC cubicles

A PLC cubicle shall be to the same height as the remainder of the switchboard for each MCC to house the PLC equipment and instrumentation equipment. This cubicle may be integrated with the associated MCC where space and size permits. If constructed integrally with the MCC, a full-height steel barrier is to be provided between the PLC tier and any motor starters within the switchboard.

Allow a minimum of twenty percent (20%) spare slot space within the PLC rack, and include adequate space for PLC terminals and field wiring terminals in line with this specification.

### 16.4.4.4 General light and power distribution boards

Distribution boards shall not be part of an MCC but a separate unit.

Distribution boards shall be proprietary, enclosed, and with single or three-phase insulated busbars.

### 16.4.5 Outdoor switchboards

#### 16.4.5.1 Classification

Outdoor switchboards shall be used if they are to be installed externally to a building or within a wet or corrosive environment.

Examples of outdoor switchboards are:

• local control panels adjacent to mechanical machinery
• field instrument panels
• outdoor distribution boards
• outdoor MCCs
• outdoor pumping station switchboards
• wastewater pumping station cable connection boxes
• junction boxes in outdoor locations

#### 16.4.5.2 General

All outdoor switchboards must provide a minimum degree of protection IP56.

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. Where the slope guides water towards doors, the switchboard shall contain an integral designed and fit for purpose return to carry the water away.

16.4.5.3 Heat shields

The switchboard enclosures are to have a stand off heat shield with an air gap of 25mm on all exposed surfaces, including doors. The heat shield is not to protrude past the sides of the switchboard doors, have smooth 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.

16.4.5.4 Outdoor pumping station switchboards

Outdoor pumping station switchboards shall have a 24V DC IP54 LED light strip within each cubicle between the inner and outer doors.

All the light strips shall be supplied from the PLC cubicle 24V DC power supply.

The lights shall be operated from the switchboard door’s limit switches.

16.4.6 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 customer. In other scenarios the location is to be negotiated with the supply authority and Hunter Water.

The main circuit breaker, or main switch, and the bus tie shall be four-pole.

Interlocking shall be provided should the switchboard not be rated for full fault current of both transformers in parallel. Refer to 8.12 Interlocking for more information. Fault levels

16.4.6.1 Fault levels and time of duration

All switchboards shall be designed and constructed to meet or exceed the nominated fault level of the installation.

16.4.6.2 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.

16.4.7 Power monitoring

Provide a power monitor on each switchboard mains supply. The power meter shall have a remote display mounted on the door with a communication cable to the base unit. Alternatively a suitable CB with equivalent power monitoring data may be used.
Refer to 18.9 Power meters for details of the information to be brought back to SCADA from the power meter.

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.

16.4.8 Motor starter requirements

All new switchboards shall use 24V DC 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.

Modules shall be a minimum size of 200 x 600mm.

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.

16.4.9 DC distribution board

The distribution board shall be of metal construction and include a main switch, standard busbar chassis and two (2) pole DC rated distribution MCBs.

16.4.10 Local operator panel equipment

Supply and install a separate individual local operator panel adjacent to each individual drive at treatment plants, where required.

Local operator panels shall contain:

- full current isolator for motors with early break late make contact in starter control circuit up to 55 kW
- emergency stop button if required
- test start pushbutton
- test stop pushbutton
- reverse pushbutton for motors with reversing starters

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The isolator position shall be monitored in SCADA.
All control or protection equipment associated with any drive shall be mounted within the switchroom’s switchboard or MCC.

16.4.11 Generator connection panels

Unless otherwise stipulated, generator connection panels shall be designed to allow flexible single-core generator cables to a maximum 240mm², or multiples thereof, to be connected.
The design shall enable the safe connection of a generator when switchboard is live.
Generator connection panels shall be lockable, including when the generator cables are connected.

16.5 Construction

16.5.1 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.
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.

16.5.2 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.
Only use type-tested busbar systems.
Earth bars shall run full length of the switchboard and shall be extended the full length of all cable zones.
Pre-drilled holes at each end of the earth and busbars shall be provided to allow for future extension of the switchboards.

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Version 4 authorised by Lutz Backhausen on 05/03/2019
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.

### 16.5.3 Indoor switchboards

#### 16.5.3.1 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.

Metal finishing, 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.

#### 16.5.3.2 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.
16.5.3.3 Main switchboards and motor control centre requirements

Main switchboards and MCCs shall be:

- Constructed to the relevant parts of AS/NZS 61439:2016.
- 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 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.

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 discriminate with the upstream protective device. The installation of the handle extension shaft shall not interfere with the visibility of the circuit breaker details. Vendor-supplied stickers or similar shall be used.

Circuit breakers installed in switchboard cells shall be lockable when the door is open.

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.

16.5.4 Outdoor switchboards

16.5.4.1 General

Manufacture all switchboard metalwork (including inner doors and escutcheons) from 2.5mm aluminium grade C5251-h34.

Floor-mounted and free-standing aluminium switchboards shall be mounted on a full perimeter minimum 100mm high x 50mm wide x 6mm thick aluminium channel plinth.

Mount the operator panels and field instrument panels with the centre of the enclosure at 1.6m from the finished walkway surface on a stand fabricated from aluminium grade C5251-h34 or 316 grade stainless steel.

The stand shall be designed with no sharp edges or trip hazards and shall be robust and rigid. Ensure clearance of not less than 600mm is provided for access and maintenance around the front of all outdoor switchboards with doors open.

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.
Outdoor switchboards shall be fitted with stainless steel swing handles fitted with electrical padlocks.
Vent systems shall prevent the ingress of vermin and/or insects by the use of Termimesh, or similar.

16.5.4.2 Local operator panels
Factory-fitted gland plates shall be installed.

16.5.4.3 Outdoor pumping station switchboards
Install in the PLC cubicle a metal pocket for the storage of A3 drawings and a fold-down support base on the inside of the door to facilitate the use of a 15” laptop computer.

16.5.4.4 Wastewater pumping station cable connection boxes
Cable connection boxes shall be provided between wet wells and the switchboard.
Connection boxes shall be proprietary-type suitable for the particular application and motor rating.
The connection boxes shall be mounted on a 500mm-high stainless steel stand with stainless steel mesh or press sheet enclosing the frame. At least one side of 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.
Connection boxes and stands shall be vandal-resistant.
Connection boxes shall have tinned busbar links to connect the motor cables, using crimp lugs and a minimum of 10mm bolts. Tunnel-type terminals are unacceptable.

16.5.4.5 Junction boxes in outdoor locations
Junction boxes shall be mounted to be easily accessed and not mounted in cramped locations. The access shall comply with the switchboard accessibility requirements of AS/NZS 3000.

16.5.5 PLC cubicles
If constructed integrally with the MCC, provide a full-height steel barrier between the PLC tier and any motor starters within the switchboard.
Control equipment (24V DC/AC) and power equipment (240V AC), including wiring, shall as far as practicable be segregated.
Fully shroud all 240V equipment and terminals. LV distribution boards shall be installed in a separate cubicle.
Provide 25 millimetres between adjacent equipment.

16.5.6 Finish colours
Switchboard colours shall comply with AS 2700 and be:
- low voltage indoor switchboards: X15 light orange or RAL2000
• high voltage indoor switchboards: RAL7032 light grey, RAL7035 light grey
• internal/removable equipment panels: gloss white or RAL9010 or similar
• outdoor switchboards – inner doors: gloss white or RAL9010 or similar

16.5.7 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.

All equipment mounting pans shall be earthed using a 6mm earth wire connected to the earth bar.

16.5.8 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.

For earth continuity a 6mm² earth wire shall be connected from a 6mm stud on the gland plate to the earth bar.

16.5.9 Doors and covers

16.5.9.1 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 doors shall have a minimum swing of 135 degrees and inner doors shall have a minimum swing of 90 degrees.

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.

16.5.9.2 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.

16.5.9.3 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.

16.5.9.4 Locks and hinges

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

- MCC cubicles containing electrical equipment that:
  - a mechanical interlock on the cell main switch as described above is installed
  - 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.

Outdoor switchboards outer doors shall be fitted with stainless steel swing handles which accept standard Hunter Water padlocks and stainless steel hinges.

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.

16.5.9.5 General light and power distribution boards

All distribution boards shall be fitted with a main switch which is able to be padlocked in the off position.
16.5.10 Shrouding

All live parts within the switchboard shall provide protection of at least IP2X. Note: AS/NZS 3000 states that supply neutral is treated as live.

Where possible 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 so as access to equipment interface data buttons shall not be 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.

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

16.5.12 Local operator panel equipment

Locate local operator panels so they are readily accessible and identifiable. The local operator panel shall be visible from drive motor and driven device.

Local full current isolator switches shall be fixed on the enclosure mounting plate and mechanically interlocked with the door to prevent door opening while in the ‘On’ position. Isolators shall not be door-mounted.
16.5.13 Field instrument panels

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

Each field instrument panel shall contain:

- A means to isolate the power supply provided within each instrumentation enclosure. All instrument field cabling shall be protected against lightning in the field instrumentation panel.
- Digital display of analog value in engineering terms, viewable with the cabinet door closed. The transparent material used for the viewing window shall be suitable for use in an outdoor environment without the material turning opaque. The displays are to be visible in bright sunlight and resistant to UV rays. The use of a metal flap with a top hinge is acceptable for protection from such damage.
- Terminals for all incoming and outgoing cable cores
- Earth electrodes shall be installed at the location of each field instrumentation panel for surge protection. An insulated earth bar for surge protection earths, connected to the panel and a local earth electrode below the panel. Where instruments are mounted above tanks or where it is not possible to install an electrode below the panel up to four instruments can use a single electrode but need to be individually wired and clamped to the electrode.
- Factory-fitted gland plates shall be installed

16.5.14 Battery cabinets

Refer to Section 12 DC power supplies for additional requirements.

16.5.15 SCADA and/or automation

(a) Treatment plants and large sites shall have separate communications cubicles for the SCADA and control networks in all physical locations, e.g. switchrooms, process buildings, etc.:

   (i) SCADA network equipment shall, at a minimum, have:

   - locked access to all doors and panels
   - power supply from a UPS-backed up supply
   - all SCADA network switches/routers
   - all SCADA network communications devices
   - all SCADA network optical fibre and CAT5e/6 terminations and patch panels

Note: the SCADA network cubicle is usually a standalone enclosure.
(ii) Control network cubicles shall, at a minimum, have:

- locked access to all doors and panels
- all control network switches/routers
- all control network optical fibre and CAT5e/6 terminations and patch panels

Note: the control network cubicle shall be a separate tier bayed to the PAC/PLC tier.

Refer to STS 550 General Requirements for SCADA and Automation Systems for additional requirements.

16.5.16 Labelling

16.5.16.1 General requirements

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

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.

16.5.16.2 Fixing of labels

Labels shall be securely fixed by screws and double-sided adhesive tape. Screw holes shall be tapped into the switchboard.

Mechanically expanded plastic rivets are acceptable instead of screws inside switchboards. 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.
16.5.16.3 Labels

Provide a switchboard label which states the switchboard number, switchboard description and the source of electrical supply. Main switchboard labels shall be a minimum of 100 x 250mm, these labels shall have a minimum of three lines of text, as shown below.

<table>
<thead>
<tr>
<th>Description</th>
<th>Text size</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWITCHBOARD NUMBER</td>
<td>15mm</td>
</tr>
<tr>
<td>SWITCHBOARD DESCRIPTION</td>
<td>10mm</td>
</tr>
<tr>
<td>SWITCHBOARD SUPPLIED FROM</td>
<td>8mm</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Description</th>
<th>Text size</th>
</tr>
</thead>
<tbody>
<tr>
<td>DRIVE NUMBER</td>
<td>10mm</td>
</tr>
<tr>
<td>DRIVE DESCRIPTION</td>
<td>8mm</td>
</tr>
</tbody>
</table>

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.

16.5.16.4 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
16.5.16.5 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 tag ID, drawings reference and the setting/rating, e.g. ‘SPD 140/160A’.

16.5.16.6 Warning labels

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

16.5.16.7 Hazard markings

Where the removal of any barrier or shrouding during normal switchboard maintenance could lead to the possibility of direct contact, a label with appropriate wording shall be provided for each functional unit. An example of a suitable label is:

<table>
<thead>
<tr>
<th>Description</th>
<th>Text size</th>
</tr>
</thead>
<tbody>
<tr>
<td>DANGER</td>
<td>10mm</td>
</tr>
<tr>
<td>ISOLATE ELSEWHERE BEFORE REMOVING COVER</td>
<td>6mm</td>
</tr>
</tbody>
</table>

Additional labels shall be provided on all doors, covers and escutcheon plates or similar containing electrical equipment. Examples of suitable labels:

<table>
<thead>
<tr>
<th>Description</th>
<th>Text size</th>
</tr>
</thead>
<tbody>
<tr>
<td>DANGER</td>
<td>10mm</td>
</tr>
<tr>
<td>AUTHORISED ACCESS ONLY</td>
<td>6mm</td>
</tr>
</tbody>
</table>

and

<table>
<thead>
<tr>
<th>Description</th>
<th>Text size</th>
</tr>
</thead>
<tbody>
<tr>
<td>DANGER</td>
<td>10mm</td>
</tr>
</tbody>
</table>
These labels shall be positioned to be readily seen, on the covers of functional units, and may be proprietary adhesive type.

Safety signs, for example ‘Danger 11kV’, are to be positioned centrally below the door labels on each outer door for the highest voltage present in that cabinet. For outdoor switchboards danger notices shall be 225 x 300mm manufactured to match switchboard construction sheets with protective over-laminate and fixed to the doors by four (4) pop rivets. Adhesive only external labels are unacceptable.

16.6 Cable/wiring systems

16.6.1 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 marked at both ends with neat and clear sleeve-type identification ferrules, with a minimum lettering size of 3mm, and the markings shall agree with the endorsed circuit diagram. 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.

16.6.2 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
- 240V control active (controlled by isolator in the cell or compartment) – white
- 240V active (not fully contained within the cell or compartment) – orange
- 240V neutral – black
- ELV DC positive – brown
- ELV DC negative – grey
- protective earth – green-yellow
- functional earth – purple

For cables above 35mm², and for all double insulated cables, phase identification shall be 25mm-wide heat-shrink bands of the colours tabulated above, applied at each end.

16.6.3 Earthing of switchboards

All metal parts of the switchboard shall be bonded to earth either by mounting screws or by 6mm wire, if the parts are not mounted on the switchboard metalwork. Demountable modules shall be fitted with an earth finger which connects to the earth bar.

Each enclosure within a switchboard shall have a 6mm earth stud which has been bonded to the earth bar with a 6mm earth wire. All module doors shall be bonded to the earth stud using 2.5mm² flexible earth wire. Escutcheons shall be bonded to the earth stud with a 2.5mm² minimum sized earthing conductor.

16.6.4 Modification of switchboards

16.6.4.1 Legacy MCC control circuit voltages

When a switchboard which has existing 240V AC control circuits and requires the adding or replacement of a starter, all the starters in the switchboard shall be changed to 24V DC control.

16.6.4.2 Legacy 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.

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

The switchboard manufacturer shall provide written confirmation the switchboard has been assembled, installed, tested, and connections have been made in accordance with guidelines prior to commissioning.

### 16.7.2 Switchboard support

All freestanding MCCs and switchboards are to be bolted to a heavy-duty stand anchored to a permanent floor.

#### 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 and located so the support frame allows for incoming and outgoing cables. Switchboard support frames shall be hot-dip galvanised mild steel with appropriate corrosion mitigation, if required.

#### 16.7.2.2 Outdoor locations

Supports for outdoor switchboards shall be fabricated from the same material as that of the switchboard, e.g. stainless steel switchboards shall have stainless steel supports. Switchboards 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 to mitigate against water entry.
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](image1.png)  ![Negative phase rotation](image2.png)

16.8 High voltage switchboards

16.8.1 Key ratings and features

The key ratings and features of the HV switchboard shall be as follows:

<table>
<thead>
<tr>
<th>Ref</th>
<th>Rating or feature</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Construction</td>
<td>Fully type-tested enclosed switchgear</td>
</tr>
<tr>
<td>2</td>
<td>Form of segregation</td>
<td>Form 4b</td>
</tr>
<tr>
<td>3</td>
<td>Class</td>
<td>Indoor</td>
</tr>
<tr>
<td>4</td>
<td>Access</td>
<td>Front access</td>
</tr>
<tr>
<td>5</td>
<td>Material of enclosure</td>
<td>Steel</td>
</tr>
<tr>
<td>6</td>
<td>Insulation medium</td>
<td>Air</td>
</tr>
<tr>
<td>7</td>
<td>Conductor material</td>
<td>Copper</td>
</tr>
<tr>
<td>Ref</td>
<td>Rating or feature</td>
<td>Requirement</td>
</tr>
<tr>
<td>-----</td>
<td>------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>8</td>
<td>Mounting arrangement</td>
<td>Freestanding floor mounted on a hot-dipped galvanised plinth</td>
</tr>
<tr>
<td>9</td>
<td>Loss of service continuity category</td>
<td>AIS withdrawable switchgear – LSC2B</td>
</tr>
<tr>
<td>10</td>
<td>Partitions and shutters</td>
<td>Class PM – metallic partitions</td>
</tr>
<tr>
<td>11</td>
<td>Minimum internal fault protection classification</td>
<td>IAC A FLR 16kA 1s</td>
</tr>
</tbody>
</table>
| 12  | Accessibility of compartments | Busbar - tool-based  
|     |                  | CB/switchgear - interlocked/tool-based  
|     |                  | Cable - tool-based |
| 13  | HV cable connection | Front (preferred) |
| 14  | HV cable entry | Bottom |
| 15  | LV and ELV cable entry | Bottom |
| 16  | Gland plate | 6mm brass undrilled |
| 17  | Degree of protection | Enclosure – IP4X  
|     |                  | Inside compartments – IP2X |
| 18  | Circuit breaker | Vacuum, SF6 outdoor use only |
| 19  | HV contactor | Vacuum |
| 20  | Maximum overall height | 2300mm |
| 21  | Height to centreline of highest equipment on LV compartment door | Preferred: 1800mm  
<p>|     |                  | Maximum: 2000mm |
| 22  | Gas discharge tunnel | Required |
| 23  | Anti-condensation heaters | Required |
| 24  | Control supply voltage | 24V DC |
| 25  | Trip/close coil voltage | 24V DC |</p>
<table>
<thead>
<tr>
<th>Ref</th>
<th>Rating or feature</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>Spring charge motor voltage</td>
<td>24V DC</td>
</tr>
<tr>
<td>27</td>
<td>HV switchboard anti-condensation heater voltage</td>
<td>240V AC ± 10%</td>
</tr>
<tr>
<td>28</td>
<td>IP rating</td>
<td>IP56 – outdoors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IP54 – indoors</td>
</tr>
</tbody>
</table>

Note: Indoors refers to inside a pressurised switchroom. All other environments are to be treated as outdoors.

### 16.8.2 Standardisation

Equipment shall be designed with standard parts and components readily available in Australia. Parts and components shall be standardised as much as possible. All replaceable and consumable equipment shall be standard supply equipment. The use of ‘one-off’ special designs is unacceptable.

### 16.8.3 Design and construction

#### 16.8.3.1 General

In addition to the previously defined switchboard requirements in 16 Switchboards, additional requirements are detailed below.

The switchboard enclosures shall comply with *AS 62271.200*.

Separate compartments shall be provided within each panel of the switchboard for:

- main busbar
- circuit breaker
- cable terminations and cable-side CTs and VTs
- LV/ELV protection, control, metering and communication equipment

All non-withdrawable switchgear shall be supplied and mounted on a 100mm-high plinth. The plinth shall be typically of hot-dip galvanised construction.

Gas discharge tunnels shall be provided if there is insufficient height above the switchboard, or the switchroom has not been designed to dissipate arc fault gases without danger to personnel.

Arc fault detection systems shall be installed in the busbar sections of the switchboard. The detection system shall be interlocked with the incoming supplies, and alarmed to the PLC/SCADA system. The design shall consider both light and current to ensure inadvertent trips do not occur.

A separate LV compartment for LV/ELV control, monitoring, protection, and indication is to form part of each panel located above the relevant HV panel with access for ELV/LV wiring.
All LV and ELV contactors, relays, instruments and other similar items shall be arranged so they may be removed and replaced with safety when the associated HV circuit is de-energised but the other HV circuits on the rest of the switchboard are energised.

Each HV functional unit shall be installed in a separate panel. All equipment associated with an individual functional unit shall be accommodated in the respective panel.

Only cables associated with a functional unit may enter the cable termination chamber of the unit. Under no circumstances shall cables from other functional units pass through the cable termination chamber of the unit.

Each panel in the switchboard shall be wired to be independently fully isolated of all auxiliary power supplies for protection, control and metering functions.

Cut-outs in the sheet metal through which wiring passes shall be bushed with male and female screwed bushes. If cut-outs are greater than 50mm in diameter or of a non-circular shape, the edges shall be fitted with a neoprene extrusion having a return of no less than 10mm on each side. Such bushings shall be neatly fitted to cover the metal completely, and securely cemented into position.

Type test certificates for the switchboard, incorporating cable boxes and all other accessories shall be supplied by the contractor.

16.8.3.2 Switchgear

Vacuum circuit breakers shall be used for:

- incoming feeder circuits
- transformer feeder circuits
- bus interconnector circuits
- VSD feeder circuits

Fused vacuum contactors shall be used for:

- direct on-line motor starting circuits

16.8.3.3 High voltage cable termination

The switchgear shall be designed for high voltage cable termination using either bolted air-insulated connections or plug and socket connections.

The high voltage cable terminations, including all necessary accessories, shall withstand the voltage impulse test applied to the switchboard.

The high voltage cable terminations shall be designed to ensure thermal, mechanical, electrical and dielectric compatibility with the switchgear.

The switchboard design shall make provision for the installation of fire-stopping material, providing a two-hour fire rating between the switchboard and the cable basement, or subfloor of the switchroom.
Adequate space shall be provided within each cable termination compartment for entry, dressing and termination of cables, including sufficient space for safe access by technicians for initial cable termination, and subsequent testing and inspection.

Cables termination facilities shall be suitable for use with termination kits readily available in Australia.

Cable connection points shall be located directly above the corresponding cable entries.

Cable entries for single-core cables shall be designed to minimise the possibility of eddy current heating.

16.8.3.4 Earthing

Earthing switches shall be provided as detailed in 14.6 Earthing switches.

All incoming and outgoing circuits shall be provided with a suitable method of earthing the HV cables for maintenance purposes. Actual earthing shall be carried out by a fault-make load-break switch. All earth switches shall be provided with mechanical interlocks to ensure that the earth switch cannot be closed onto a ‘Live’ circuit.

A method to earth the bus system shall be provided.

16.8.3.5 Live line indication

Live line capacitive voltage divider neon indicators shall be fitted:

- on the cable-side of all VCBs and FVCs
- on the busbar-side of the busbar earth switch

Operation

It shall be possible for one (1) operator to perform all switchgear operations, including bus disconnection, earth switch operation, and circuit breaker open and close, with all compartment doors closed and secured.

The switchboard shall be designed for remote operation and local operation. All local operating functions shall be capable of being carried out by an operator standing in front of a switchboard at floor level.

For withdrawable voltage transformers, it shall be possible to rack-in, rack-out and lock any isolating bus shutters by an operator standing at floor level. Where operation of any equipment while standing in front of switchboard at floor level is not achievable, the contractor shall provide a suitable means of safe access to operate the equipment.

All operating mechanisms, including circuit breaker closure control, must be able to be padlocked.

A test mode shall be provided to enable the switch unit to be operated when isolated from the supply busbars, i.e. with busbar disconnected. This shall allow the testing of all auxiliary circuits and mechanical functions, and enable the circuit breaker to be operated.

Address the issues outlined in Annex A1, 2, 3, 4, 5, 6, 7 and 8 of AS 62271.200 in demonstrating the arc containment capabilities of the switchgear offered.
16.8.3.6 LV compartment door

No LV equipment shall be installed on LV compartment doors.

16.8.3.7 Anti-condensation heaters

Separate anti-condensation heaters shall be provided within each HV cable compartment and each LV compartment of each switchboard tier.

The auxiliary supply voltage for anti-condensation heaters shall be 240V AC ± 10%.

Anti-condensation heaters shall be controlled by means of individual thermostats within each compartment.

Isolating circuit breakers within each LV compartment are to be provided for the anti-condensation heaters within that tier.

The anti-condensation heaters, thermostats, and wiring terminations shall be guarded and/or shrouded to prevent personnel inadvertently contacting hot surfaces or live terminals during testing, commissioning or routine service and maintenance activities.

16.8.3.8 Interfaces with external systems and equipment

Interfaces between the switchboard and external systems and equipment shall be provided in accordance with this STS.

Such interfaces shall include:

- DIs, AIs and DOs to and from a plant’s PLC via the communications interfaces
- hardwired alarm and trip inputs from transformer protection devices
- hardwired inter-trip signals to and from a substation and HV switchgear
- hardwired CB fail signals to and from a substation and HV switchgear
- hardwired CT and VT signals to the metering systems
- hardwired CT signals from REF neutral CTs

All hardwired digital outputs shall be volt-free contacts.

All hardwired digital inputs shall be from volt-free contacts.

All hardwired CT and VT secondary signals to external systems shall be provided with disconnect/test terminals.

All hardwired VT secondary signals to external systems shall be provided with a suitably rated MCB for protection and isolation of the external equipment.
16.8.4 Testing requirements

16.8.4.1 Type testing

Type test reports shall be provided by the contractor for switchboard enclosures, VCBs, FVCs, and earth switches for all type tests listed within:

- **AS 62271.100** HV switchgear and control gear - HV AC circuit-breakers
- **AS 62271.102** HV switchgear and control gear - AC disconnectors and earthing switches
- **AS 62271.200** HV switchgear and control gear - AC metal-enclosed switchgear and control gear for rated voltages above 1kV and up to and including 52kV
- **AS 60470** HV AC contactors and contactor-based motor-starters

A covering report shall be provided by the contractor that includes:

- details of the design of the type tested equipment, including drawings
- an explanation of why any differences do not affect the integrity of the type tests
- full copies of any type test reports

If new type tests are performed, representatives from the principal shall be given the opportunity to witness the tests. Fourteen (14) calendar days’ notice shall be given for tests in Australia and twenty-one (21) calendar days’ notice shall be given for tests outside Australia.

Copies of all type test reports, whether previous or new, shall be submitted by the contractor to the principal.

Applicable type tests reports for other equipment, components, protection relays, and the like shall be provided by the contractor upon request by the principal.

16.8.4.2 Routine (factory) testing

Perform routine (factory) tests on each tier of switchgear prior to shipment to site. Such tests shall include all routine tests listed within:

- **AS 62271.100** HV switchgear and control gear - HV AC circuit-breakers.
- **AS 62271.102** HV switchgear and control gear - AC disconnectors and earthing switches.
- **AS 62271.200** HV switchgear and control gear - AC metal-enclosed switchgear and control gear for rated voltages above 1kV and up to and including 52kV.

Routine (factory) tests shall include:

- detailed mechanical inspection
- detailed electrical inspection
- verification of correct labelling
- mechanical tests on all mechanical interlocking, key interlocking and padlocking systems
• mechanical tests on all VCBs earth switches
• mechanical tests on all FVCs earth switches
• electrical tests on all electrical interlocking and synch-check systems
• review of setup parameters for all digital protection relays
• functional tests on all operations counters, position indicators, capacitive voltage indicators, and the like
• functional testing of all control and indication circuits
• functional testing of all protection circuits via secondary injection
• primary and secondary injection testing shall be carried out at a minimum of three (3) current settings to verify correct operation of protection relays
• functional testing of all metering circuits
• insulation resistance tests (before dielectric withstand tests)
• dielectric withstand tests (power frequency tests)
• insulation resistance tests (repeated after dielectric withstand tests)
• LV wiring flash tests (insulation resistance/dielectric withstand/insulation resistance)
• HV circuit resistance (Ductor) test between main busbar tags and outgoing cable tags
• inspection of all loose-supplied equipment
• verification of all CT ratios and polarity of all CT connections
• partial discharge tests on all CTs and VTs, if not already performed at the place of manufacture
• magnetisation tests on all CTs, if not already performed at the place of manufacture
• review of routine test certificates for VCBs, FVCs, CTs and VTs from place of manufacture
• review of routine test certificates (to IEC 60255) for digital protection relays from place of manufacture
• review of manufacturing inspection and test documentation and records
• review of manufacturing defect lists/punch lists

Representatives from the principal shall be given the opportunity to witness the factory acceptance tests. Fourteen (14) calendar days' notice shall be given for tests in Australia and twenty-one (21) calendar days' notice shall be given for tests outside Australia.

The results of all factory acceptance tests shall be available for review.

A comprehensive factory acceptance test report shall be submitted to the principal within five (5) working days of completion of the tests for that switchboard or prior to shipment, whichever is earlier. The report shall include:

• results of all tests
• copies of any test oscillograms, graphs, printouts, and the like
• copies of all routine test certificates, from place of manufacture, for VCBs, FVCs, CTs and VTs

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copies of all routine test certificates (from place of manufacture) for digital protection relays
copies of manufacturing inspection and test documentation and records, follower cards, and the like
copies of factory defect lists/punch lists
copy of a completed factory ITP
statement confirming compliance with specified requirements

All defects arising prior to or during the factory acceptance tests shall be rectified to the satisfaction of the principal prior to equipment being shipped to site.

16.8.4.3 Site testing

After assembly on-site, the contractor shall perform detailed tests to verify each HV switchboard is complete and ready for energising. The contractor shall complete pre-commissioning checks, for each panel incorporated in the HV switchboard.

Such site tests shall comply with the applicable requirements of:

- **AS 62271.100**  
  HV switchgear and control gear – HV AC circuit-breakers

- **AS 62271.102**  
  HV switchgear and control gear – AC disconnectors and earthing switches.

- **AS 62271.200**  
  HV switchgear and control gear – AC metal-enclosed switchgear and control gear for rated voltages above 1kV, up to and including 52kV

- **AS 60470**  
  HV AC contactors and contactor-based motor-starters

As a minimum, the following tests shall be performed:

- detailed mechanical inspection
- detailed electrical inspection (including termination of inter-tier wiring)
- mechanical tests on all mechanical interlocking, key interlocking and padlocking systems
- mechanical tests on all VCBs, earth switches
- mechanical tests on all FVCs, earth switches
- electrical tests on all electrical interlocking and synch-check systems
- check of setup parameters for all digital protection relays
- functional tests on all operations counters, position indicators, capacitive voltage indicators, and the like
- functional testing of all control and indication circuits
- functional testing of all protection circuits via secondary injection
- primary and secondary injection testing shall be carried out at a minimum of three (3) current settings to verify correct operation of protection relays
- functional testing of all metering circuits
- insulation resistance tests (before dielectric withstand tests)
- dielectric withstand tests (power frequency tests)
- insulation resistance tests (repeated after dielectric withstand tests)
- LV wiring flash tests (insulation resistance/dielectric withstand/insulation resistance)
- HV circuit resistance (Ductor) tests between main busbars and outgoing cable tags
- HV circuit resistance (Ductor) along main busbars
- inspection of all loose-supplied equipment
- review of assembly inspection and test documentation and records
- review of assembly defect lists/punch lists

Representatives from the principal shall be given the opportunity to witness the site tests.

A comprehensive site test report shall be submitted to the principal for approval within five (5) working days of completion of the tests, or on handover, whichever is earlier. The site test report shall include:

- results of all tests
- copies of any test oscillograms, graphs, printouts, and the like
- copies of site defect lists/punch lists
- a copy of the completed site ITP
- a statement confirming compliance with all specified and legislated requirements

16.8.5 Operating tools

One (1) complete set of operating tools shall be supplied for the HV switchboard including:

- manual spring charge handle
- earth switch operating handle
- VCB racking handle
- FVC racking handle
- one three-phase set of HV test plugs for insertion into busbar or cable-side spouts
- trolley for VCB truck
- trolley for FVC truck
- one set of VCB truck test leads
- one set of FVC truck test leads
- two (2) matching test plugs with leads for protection relays

Notes:

1. Where the VCB and FVC use the same truck or test leads, only one (1) set of each is required.
2. Trolleys for VCB trucks or FVC trucks shall be lockable to the switchboard during the insertion or removal of a truck.
17 Switchrooms

17.1 Submissions

The following reports shall be submitted:

- calculations to demonstrate compliance with required cooling system capacities
- proposed details of any VSD or AHF venting systems for approval prior to procurement
- arc flash study
- earthing study

17.2 ITPs

ITPs shall include:

- operation of all alarms and trips, and display them in HMI and SCADA
- correct display of all required monitoring points in HMI and SCADA

17.3 General

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

Switchroom subfloor must contain a sump 300 x 300 x 300mm. A pit float switch shall be installed in all pits to register an alarm on SCADA when a pit floods.

Indoor walls shall be finished white paint to AS 2700 and paint colour N14.

Walls shall be masonry or concrete, and ceilings shall be of non-combustible materials.

17.4 Concrete reinforcing

Refer to 9.5 Equipment earthing.

17.5 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.

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.

17.6 Arc flash mitigation

Switch rooms shall be designed so heated gases and subsequent pressure waves from any switchboard arc flash blasts are directed away from persons in front of the switchboard when the switchboard doors are closed. Cables and other assets in the vicinity of arc flash pressure relief vents shall also be protected from such events.
Arc flash studies shall determine the maximum impact of such events in the immediate vicinity of blasts and minimum separation distances from pressure relief vents required for persons, unprotected cables and other assets.

### 17.7 Fire-resistance level

When a switchroom is part of another building, is attached to a building, within three meters of another building, or in areas susceptible to bushfire, the walls, ceiling, floor, and doors are to be constructed to a fire-resistance level of 120/120/120.

### 17.8 Flooring

LV switchroom floors shall be modular extra heavy-duty computer/equipment room access type, with removable panels for access to cabling under the floor, with a minimum height of 600mm.

Access floors shall have high pressure laminate panel surface finishes ready for installation and immediate use. Access floors shall be rigid, free from vibration and rocking panels and within a ±3mm level over the entire space. Panels shall be accurately cut to fit around all permanent features.

All panels are to provide zero fire hazard indices under AS 1530.4. All whole panels shall be interchangeable, allowing for any future changes. Access floors shall maintain these original conditions when runs of panels have been removed for normal underfloor access.

The weight of switchboards, freestanding VSDs, PFCs, AHFs, or other SCAs shall not be supported on computer type elevated floors.

Supply lifting handles suitable to lift floor plates in each switchroom.

### 17.9 Doors

Switchroom doors shall comply with AS/NZS 3000.

Doors shall open outwards and be fitted with crash bars that operate independently of the lock on the outside and have a two-hour fire rating. One of these doorways shall be sized to allow for the largest individual switchboard to be installed or removed easily.

The threshold beneath each door shall be flush, designed to ensure correct operation of all seals and allow for rolling of a switchboard.

### 17.10 Lighting

Lighting shall be a minimum of 240 lux at ground level with an emergency light in every second fitting. Facilities for testing emergency lights shall be provided, as per AS 2293 and AS 1680.

Emergency exit lights are required above each exit point. Provide a LED light external above each door operated by a sunset switch and a manual override test functionality.
17.11 Smoke and fire detection

Smoke detectors shall be installed in switch rooms. Smoke detectors shall be hardwired and connected to the PLC/SCADA system.

For switch rooms fed from transformers capable of supplying 800kVA and above, a VESDA system shall be installed which samples from under floors and above switchboards. An audible alarm shall be installed in the switchroom. Fire extinguishers (CO₂) shall be provided near each door, as per AS 2444.

17.12 Signage

Signage shall be fitted externally to each set of doors of the switchroom as follows:

- Name of the switchroom: 150 x 450mm
- Danger 415V: 200 x 300mm
- Authorised persons only to enter: 200 x 300mm

Signs shall have aluminium backing with PVC printing.

Main switches shall be clearly labelled so to be easily located in emergencies.

Boards shall be fixed to the internal walls of all switchrooms, with CPR charts and laminated A3 SLDs.

All equipment or features installed in subfloors require prior approval. All equipment or features installed in subfloors shall be clearly identified by traffolyte labels mounted 400mm above finished floor levels.

Nothing is to be located on the finished floor that would block these signs or prohibit access for maintenance purposes.

17.13 Air quality

Provide an air conditioning system for each switchroom. Each switchroom air conditioning system shall consist of a minimum of two separate independent air conditioning units. These units shall be sized to maintain an internal room temperature of at least:

- 25°C when N air conditioning systems are operating
- 35°C when N-1 air conditioner is running

Each switchroom air conditioning system shall be rated to achieve the above performance levels with an outside ambient temperature of 45°C and all electrical equipment inside the switchroom operating at full load. Provide a switchroom RTD connected to the PLC system to monitor switchroom temperature and have an alarm set to 30°C. Each air conditioning unit shall be monitored for availability via the PLC.

Air conditioning systems shall retain temperature settings and automatically resume operation after power supply interruption. Air conditioners shall be configured to shut down during cold weather and not switch to the heat cycle.

For switchrooms with a number of large VSD and AHF (over 100 kW), consideration shall be given to venting the hot-air exhaust externally to limit the loading on the air conditioning system.
Where corrosive, e.g. salty air, or toxic gases are present outside the switchroom, provide suitable measures to prevent introduction of these gases into the switchroom. These switch rooms shall have positive pressure of 25kPa inside to prevent the entry of gases and contaminants.

Handheld remote control devices for air conditioning shall be wall-mounted in the switchroom.

Hardwired controllers shall be easily accessible and at a suitable height for use.

17.14 Pathways

Where a switchroom is a self-contained building, a continuous pathway shall be provided around the building. The pathway shall be a minimum of 600mm wide. This width is in addition to the width of any plinths installed for equipment such as gas suppression systems or air conditioners.

17.15 Awnings

Awnings shall be installed above any outside doorways.

17.16 Miscellaneous

Provide a 450 x 900 x 1800mm metal cabinet with shelves to store drawings, a two-drawer desk and a chair with five castors, to allow for reading of drawings.

Switchroom penetrations shall be sealed. Fire resistance shall be maintained.
18 Instrumentation and control

18.1 Submissions

The following reports shall be submitted with the design:

- a piping and instrumentation diagram for treatment plant upgrades
- SCADA and control network design

18.2 ITPs

ITPs shall include:

- 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 instrument without nuisance signals
- correct configuration of device

18.3 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 instruments shall be loop powered or powered from 24V DC. Analog signal transmission shall be linear, 4 - 20mA DC 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.
18.4 Control of equipment

All electrical equipment shall be supplied and controlled from a plant switchboard or MCC. Local switching panels shall not be used. More complex equipment such as UV may be placed in the field with written approval from Hunter Water.

18.5 PLC, SCADA and telemetry

18.5.1 General

Digital inputs and outputs shall be 24V DC and interfaced by a 24V DC relay with gold-flashed contacts. Analog input/output shall be 4 - 20mA, current sinking or sourcing as required and fully short circuit protected.

Connect all inputs and outputs to wiring using disconnect terminals. Each input/output point that connects to equipment in the field shall be suitably protected by a fuse.

18.5.2 PLC hardware

18.5.2.1 Treatment plants

PLCs shall be Schneider M580. The PLC shall be selected to maintain at least 50% spare memory capacity.

PLC racks, digital and analogue inputs and outputs, and communications modules shall be mounted in a PLC/instrumentation cubicle.

18.5.2.2 Pumping stations

PLC CPUs shall be Schneider M580 with SCADAPack 334E telemetry unit.

18.5.2.3 Flow meters, reservoirs and other small installations

Remote telemetry units shall be used as PLCS at small installations, such as flowmeters or reservoir sites.

18.5.3 Telemetry

Telemetry systems shall be installed with battery back-up systems that shall:

- Power the telemetry system for a minimum of four hours.
- Recharge once external power is restored.

18.6 Control and protection relays

18.6.1 Control relays

All control relays shall be 24V DC and block type for all control applications.
18.6.2 Digital protection relays

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

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.

Human-machine interfaces (HMI)
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.

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.

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.

**Trip circuit supervision (TCS)**

This shall be achieved integrally within the digital protection relay or via a separate trip circuit supervision relay.

**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.

**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.

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

18.6.3 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.

18.7 Control switches, pushbuttons and indication

18.7.1 Selector switches

18.7.1.1 Switch mode definition

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

18.7.1.2 Switch configuration

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

- Off: toggle pointing vertically up
- Test: toggle pointing 45° to the left of vertical
- Auto: toggle pointing 45° 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.

18.7.2 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
18.7.2.1 Stop buttons

Stop buttons shall be red and non-latching.

18.7.2.2 Emergency stops

A risk assessment shall be completed to determine if an emergency stop is required to mitigate against unacceptable risk to personnel. Should an emergency stop be required, it shall be designed, installed and commissioned to comply with relevant standards. As an example, category 2 or category 4 as per AS 4024. Examples of emergency stop devices: emergency stop buttons, whole current isolators, and lanyards.

Emergency stops shall not be installed for protection of equipment. Written request for exemption shall be submitted to the principal if an emergency stop is requested for equipment protection.

Emergency stop buttons shall be installed as per AS 4024.

18.7.3 Operational indication lights

Use super bright type LED indicator lights. All indication lights shall have press to test.

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

18.8 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

Ammeters subject to motor-starting currents shall be over scaled a minimum of five times.

18.9 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 have remote displays where the following parameters can be displayed:

- 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)

18.10 Low voltage current transformers

Current transformers for electricity distributors’ equipment shall comply with the requirements of the provider.

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.

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.
18.11 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
- 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 back-filled 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.

18.12 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

18.13 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.

18.14 Level measurement devices

18.14.1 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

18.14.2 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.

18.14.3 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.

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18.14.4 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.

18.14.5 Conductivity level switches

Conductivity level switches shall not be used.

18.15 Flow measurement devices

18.15.1 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.

18.15.2 Electromagnetic flow metering

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 alphanumerid 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:

a) Construction materials shall be selected to provide consistent reliable operation for the life of the meter in the operating conditions

b) 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.

c) All copper alloys in contact with water shall comply with AS 2345

d) Materials in contact with drinking water shall comply with AS/NZS 4020

e) Shall comply with HWC standards for materials in contact with potable water.

f) All flow meters shall comply with AS 3565.1 in regards to material durability tests.

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 AS1768 so as to
prevent the connected infrastructure from generating unacceptable touch voltages as specified in
AS3000. 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.

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.

**Flow Tube Liner and Electrodes**

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

**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.

**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.

**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.

**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.

**Electrical Installation**

Meters shall operate from a 24VDC power supply. Where practicable, this 24VDC supply will be supported by a 24VDC 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 signal)

For bidirectional flow:

- Forward flow rate (analogue)
- Reverse flow rate (analogue)
- Forward totalised volume increment (pulse digital)
- Reverse totalised volume increment (pulse digital)
- General fault (digital signal)
- 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 be include an integral digital indicator calibrated in engineering volumetric flow rate units (L/s) for all applications. The flow meter shall display instantaneous flow and totalised flow.

The flow meter shall also incorporate forward and reverse flow indication, and shall provide a forward/reverse contact. This shall be displayed as a positive/negative value on the SCADA system.

**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.

**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 by the use of 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.
Diagnostics

All electromagnetic flow meters shall be provided with on-board diagnostics that have the ability to 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.

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.

18.15.3 Thermoelectric flowmeters

Air-flow 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 (Nm³/hr).

The overall accuracy of transmitters and sensors shall be better than ± 2% of reading, repeatability ± 1% of reading, and turndown: 5:1 to 100:1 maximum.

Example of use:

- Air-flow measurements from blowers

18.15.4 Thermoelectric flow switch

Thermoelectric flow switches may be used for flow indication in situations where there is no requirement for analog 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 24V DC.

Example of use:

- process dilution water or cooling water flow indication

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18.15.5 **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

18.16 **Pressure measurement devices**

18.16.1 **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

18.16.2 **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

18.16.3 **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

18.17 **Analytical measurement devices**

18.17.1 **Dissolved oxygen (DO) measurement devices**

Temperature compensation shall be included in measuring systems.

Convert signals derived from DO sensors to an isolated 4 - 20mA DC 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

18.17.2 **Redox measurement devices**

Temperature compensation shall be included in measuring systems.

Convert signals derived from sensors to an isolated 4 - 20mA DC 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

18.17.3 **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

18.17.4 **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

**18.18 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

**18.19 Instrumentation in PLC cubicles**

**18.19.1 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.

**18.19.2 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 24V DC 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

### 18.20 Solenoid valves

Without written exemption from the Principal, all solenoid valve coils shall operate on 24V DC. The solenoid shall have a varistor, flyback diodes and safety fuse. All coils shall be continuously rated 24V DC 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 Distribution transformers and substations

19.1 Submissions

The following reports shall be submitted:

- bill of materials
- general arrangements
- expected maximum levels of standard dissolved gas analysis gases in transformer oil after six months of energisation

19.2 Witness points

Factory acceptance tests shall be witnessed.

19.3 ITPs

Details of the exact test are listed in 19.9 Testing. These include:

- impulse test (type test)
- temperature rise test (type test)
- short duration and long duration withstand tests
- sound pressure test (special test)
- short circuit test for transformers
- all routine tests listed by AS/NZS 60076.1
- dissolved gas analysis at FAT, SAT, one month, six months and twelve months after energisation
- partial discharge at FAT and SAT, maximum level to be <10pC, kiosk levels shall be achieved with all switchgear connected

19.4 Key ratings and features

The key ratings and features of transformers shall be as follows:

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<th>Ref</th>
<th>Rating or feature</th>
<th>Requirement</th>
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<th>Pad mount kiosk TX</th>
<th>Pole-mount TX</th>
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<td>4</td>
<td>Kiosk enclosure</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Impedance voltage at MCR at principal tap</td>
<td>To be determined by contractor</td>
<td>To be determined by contractor</td>
<td>To be determined by contractor</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>X/R ratio at MCR</td>
<td>To be determined by contractor</td>
<td>To be determined by contractor</td>
<td>To be determined by contractor</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>System fault level</td>
<td>Refer specification – if not specified, to be determined by contractor</td>
<td>Refer specification – if not specified, to be determined by contractor</td>
<td>Refer specification – if not specified, to be determined by contractor</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Neutral earthing system</td>
<td>415V star point solidly earthed</td>
<td>415V star point solidly earthed</td>
<td>415V star point solidly earthed</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Tappings</td>
<td>Six (6) positions on primary winding +5.0%, +2.5%, 0%, -2.5%, -5.0%, -7.5%</td>
<td>Six (6) positions on primary winding +5.0%, +2.5%, 0%, -2.5%, -5.0%, -7.5%</td>
<td>Six (6) positions on primary winding +5.0%, +2.5%, 0%, -2.5%, -5.0%, -7.5%</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Tap changer</td>
<td>Off-load (able to be padlocked)</td>
<td>Off-load (able to be padlocked)</td>
<td>Off-load (able to be padlocked)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>HV winding connections</td>
<td>Cable box for bottom entry cables</td>
<td>Insulated fittings</td>
<td>Bushing</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>LV winding connections</td>
<td>Cable box for bottom entry cables</td>
<td>Cables shall have protected cover to prevent inadvertent touching</td>
<td>Bushing</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Winding temperature indicator (c/w adjustable alarm and trip)</td>
<td>Yes</td>
<td>Yes</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Oil type</td>
<td>FR3 organic oil</td>
<td>FR3 organic oil</td>
<td>FR3 organic oil</td>
<td></td>
</tr>
</tbody>
</table>
19.5 Power system conditions

Transformers shall be designed and installed to meet the requirements outlined in AS 2067.

Transformers shall be designed to suit the following power system conditions for the voltages present at the respective sites:

Common data

<table>
<thead>
<tr>
<th>Ref</th>
<th>Power system condition</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Power frequency</td>
<td>50Hz</td>
</tr>
<tr>
<td>2</td>
<td>Power factor</td>
<td>0.8 lag to 0.8 lead (over the entire tapping range)</td>
</tr>
<tr>
<td>3</td>
<td>Load profile</td>
<td>Continuously variable across 0-100% of MCR</td>
</tr>
</tbody>
</table>

Transformer data requirements

<table>
<thead>
<tr>
<th>Ref</th>
<th>Power system condition</th>
<th>Transformer primary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>415V</td>
</tr>
<tr>
<td>1</td>
<td>Nominal system voltage</td>
<td>415V AC</td>
</tr>
</tbody>
</table>
2 | Maximum system voltage (steady state) $U_{\text{max}}$ | 457V AC | 760V AC | 3.6kV AC | 12kV AC | 36kV AC |
---|-----------------|---------|---------|---------|--------|--------|
3 | Lightning impulse withstand voltage (1.2/50 µs wave) | n/a | n/a | 40kVp | 95kVp | 200kVp |
4 | Power frequency withstand voltage | 2kV AC | 3kV AC | 10kV AC | 28kV AC | 70kV AC |

19.6 Special requirements for coastal and harsh environments

Where an asset is installed externally and within 2,000m of the ocean, or 1,000m from a still salt water body such as Lake Macquarie, Newcastle Harbour or Nelson Bay or where nominated by Hunter Water, it shall conform to the rest of this standard and shall have all of the general requirements above, with the following alterations.

General:
- There shall be no exposed copper to the atmosphere (including busbars behind shrouds).
- Exposed metal surfaces shall be either:
  - 316 stainless steel,
  - Marine-grade aluminium
  - installed in IP56 enclosure, or
  - have corrosion-resistant covering, such as epoxy top coat or heat shrink
- Structural steel shall be hot-dipped galvanised.

Kiosk enclosures:
- The outer enclosure, integral internal oil bund and ventilation louvres shall be fabricated from marine-grade aluminium or fibreglass, instead of mild steel.
- Passive air filters shall be installed on louvres to prevent the ingress of salt-laden moisture.

Transformers:
- Transformers shall be finished in a corrosion-resistant epoxy top coat, instead of a standard top coat, or be galvanized mild steel sheet, fully welded construction.
- Exposed conductors (braid, copper bus bar, flexible bus bar, cables) shall:
  - be fully insulated
  - tinned to a minimum 10 microns
  - use stainless steel lugs and fittings
  - all lugs to be covered with heat shrink
19.7 Construction

19.7.1 General

Galvanized plates that have been cut shall have the edges treated for corrosion.

19.7.2 Fixings

All fixings shall be 316 stainless steel. Fixings include, but are not limited to: saddles, bolts, nuts, washers, flexible conduit, and screws.

19.7.3 Windings

Transformers shall have separate three-phase primary and secondary windings suitable for connection to three-phase 50 Hz supply systems. Fully rated taps shall be provided in the primary windings.

Neutral conductors between star points and neutral bushings shall be dimensioned to carry the rated phase current of the transformer and the worst-case earth-fault current.

Windings shall be adequately braced against all possible mechanical forces arising under short-circuit conditions.

Winding assemblies shall be pre-shrunk during construction to minimise shrinkage during the service life of transformers.

Contractors shall select either aluminium or copper materials for the primary and secondary windings based on design optimisation of transformer losses, short-circuit performance, etc.

19.7.4 Tank and core

Transformer tanks shall be constructed to withstand, without damage, mechanical stresses and internal pressures that may occur in normal service, and those during short-circuit conditions, transport or handling during manufacture, testing, installation, inspection, maintenance, and repair.

Tanks shall be fabricated from welded mild steel plate.

All external welding, including that for external bracing, shall be continuously welded along the upper line to prevent moisture from lodging behind welds.

Attachments shall be provided for lifting so that cores are readily removable from tanks for inspection.

Cores shall be secured from movement inside tanks during normal handling and transport, and fully supported when installed within.

Clamping arrangements shall be provided so that when the core, windings and supporting framework are assembled, the general structure forms a rigid assembly unaffected by short-circuit conditions, transport or handling during manufacture, testing, installation, inspection, maintenance and repair.

Cores shall be electrically bonded to the transformer tank covers.
Gaskets shall be of an oil-resistant synthetic rubber, or synthetic rubber and cork composition without textile backing, formed and cut to suit the application. Any joints shall be scarf-type.

The vacuum-withstand capability of the tank, cooling tubes and radiators shall be tested prior to installation of the core and windings.

19.7.5 Cable boxes

Cable boxes shall be fabricated from welded mild steel plate, and bolted to tanks prior to painting.

All external welding shall be continuously welded along the upper line to prevent moisture from lodging behind welds. Cable boxes shall be free from distortion and/or twisting.

Each cable box shall be sized to suit the respective number and size of cables, as determined by the final design.

Clearances for all live parts inside cable boxes shall comply with relevant Australian Standards.

The IP rating of cable boxes shall be a minimum of IP56 for both HV and LV sides.

Means of draining moisture that might accumulate inside cable boxes shall be provided.

Bottom cable entry shall be provided through undrilled, removable 6mm brass gland plates. All gland plates shall be sized so that no bending of cables is necessary inside the cable boxes. All gland plates shall also have adequate space for entry of two (2) 185mm² earth bond cables.

Access for termination, testing and inspection shall be through the front face of the cable boxes. Suitable gaskets shall be provided to maintain the IP rating.

Porcelain bushings shall protrude horizontally through the walls of the tanks into the cable boxes. The palms of the bushings shall be pre-drilled to suit the respective number and size of cables nominated by contractors. Only one (1) cable termination lug shall be bolted per pre-drilled hole. If necessary, extension palms shall be provided.

Supports shall be provided to ensure that, under no circumstance, any weight attributed to the cables is imposed on the transformer bushings. Gland plates shall not be included in the design of the cable supports.

Two (2) stainless steel earth lugs shall be provided inside each cable box, at the left and right-hand ends of the box. Each earth lug shall be pre-drilled to suit two (2) M12 bolts.

The requirements for bushings and insulators are defined in 19.7.8 Bushings and insulators.

19.7.6 External surface treatment and painting

The external surface treatment and paint system used on transformers shall comply with WSA 201 and be resistant to:

- transformer oils
- SO₂ and H₂S gas attack
- salt air
- weather
Surface preparation and paint systems shall be selected to give a life of not less than fifteen (15) years to first maintenance.

Immediately prior to the application of paint, all internal and external steel surfaces of all fabricated components shall be blast cleaned to AS 1627, Part 4, Class 2.

Paint systems shall consist of at least two (2) zinc-rich primer coats plus at least two (2) finishing coats. Each coat shall have a minimum film thickness of 60µm, giving an overall minimum paint thickness of 240µm.

Unless approved otherwise, the colour of the top coats shall be N42 Storm Grey to AS 2700. Pole mount transformers may be galvanised to manufacturer’s specifications in accordance with AS/NZS 4680.

Primers based on zinc chromate or red lead, and topcoats with polyurethane shall not be used under any circumstances.

Isocyanide-based materials shall not be used under any circumstances.

19.7.7 Fittings and protection devices

19.7.7.1 Pad mount and kiosk transformers

The following fittings and protection devices shall be provided on each transformer:

- for pad mount transformers, cable boxes complete with porcelain bushings (refer to 19.7.5 Cable boxes)
- valves of suitable size for oil filling
- valves of suitable size to facilitate in-service oil filtering and sampling
- drain valve with a metal surround to protect the valve from accidental damage
- oil-level indicator showing the oil-level reading, red floating bead against a white background, over the range of 5°C to 105°C for top oil temperature, with the oil level at 5°C indelibly marked (alternatively an oil presence indicator suitable for hermetically sealed transformers)
- a thermometer pocket accessible for the insertion of a glass thermometer and located in a position suitable for measurement of the top oil temperature
- a dial type oil temperature indicator, with instantaneous pointer (black) and maximum temperature pointer (red). The indicator shall be accessible at ground level and is to include capillary tubing between the indicator and the temperature measurement device. Volt-free adjustable alarm, trip contacts and analogue feedback are to be provided integral to the indicator and wired to a terminal box for connection to external cables.
- on 3 MVA and above transformers only, a dial type winding temperature indicator, with instantaneous pointer (black) and maximum temperature pointer (red). The indicator shall be accessible at ground level. The winding temperature sensor shall be located to measure the worst-case winding temperature rise. Volt-free adjustable alarm, trip contacts and analogue feedback shall be provided integral to the indicator and wired to a terminal box for connection to external cables.
- a sudden pressure relief valve with integral volt-free limit switch
- junction box for auxiliary circuits
- lifting lugs capable of lifting the transformer complete with oil
- tie-down lugs
- hauling and jacking lug
- two (2) stainless steel earth lugs welded to the outside of the transformer tank (on opposite sides of the tank), each predrilled to suit two M12 bolts
- one (1) stainless steel earth lug welded to the outside of each cable box, each predrilled to suit two M12 bolts
- stainless steel nameplate (refer to 19.7.14 Nameplates)
- stainless steel rating plate (refer to 19.7.15 Rating plates)

### 19.7.7.2 Pole mount transformers

The following fittings and protection devices shall be provided on each transformer:

- porcelain cable bushings
- valves of suitable sizes for oil filling
- valves of suitable sizes to facilitate oil filtering and sampling
- drain valve with a metal surround to protect the valve from accidental damage
- oil level indicator showing the oil level reading, red floating bead against a white background, over the range of 5°C to 105°C for top oil temperature, with the oil level at 5°C indelibly marked (alternatively an oil presence indicator suitable for hermetically sealed transformers)
- sudden pressure relief valve
- lifting lugs capable of lifting the transformer complete with oil
- tie-down lugs
- two (2) stainless steel earth lugs welded to the outside of the transformer tank (on opposite sides of the tank), each predrilled to suit two M12 bolts
- stainless steel nameplate (refer to 19.7.14 Nameplates)
- stainless steel rating plate (refer to 19.7.15 Rating plates)

### 19.7.8 Bushings and insulators

All bushings are to be air-insulated outdoor porcelain type.

Bushings shall comply with AS/NZS 60137.

If required, insulators shall be air-insulated indoor or outdoor porcelain type, and shall comply with AS 4398 and AS 62217.

Air clearances for all live parts shall comply with shall be built to IEC60076.

Porcelain and metal fittings shall remain unaffected by atmospheric conditions producing weathering, acids, alkalis, dust or rapid changes in temperature.

The strength of bushings and insulators as given by the electro-mechanical test load shall be such that the factor of safety when supporting their maximum working loads shall be not less than 2.5.

Warning – this document is current at time of printing or downloading. It may be reviewed and amended prior to the noted review date at the discretion of Hunter Water Corporation.
Designs shall be such that stresses due to expansion or contraction in any part of the bushings, insulators or associated fittings do not lead to defects developing.
All porcelains shall be manufactured in one piece. Jointing of solid or hollow porcelains is not permitted except by use of metal fittings. Porcelain shall be sound, free from defects and thoroughly vitrified, and the glaze shall not be depended upon for insulation. Glaze shall be smooth, hard, of a uniform shade of grey, and shall completely cover all exposed parts of the insulators.

Bushings and insulators shall be mounted and fixed in accordance with manufacturers’ instructions.

Each bushing and insulator shall be clearly marked with the manufacturer’s name or trademark, the year of manufacture and the insulator type. Marks shall be visible after assembly of fittings and shall be imprinted before firing.

19.7.9 Off load tap changers

The primary windings of the transformers shall incorporate off load tap changers.

The off load tap changer switches shall be accessible from the outside of the tanks and shall be able to be padlocked to prevent unauthorized operation.

The off load tap changer switches shall be clearly marked to show each switch position.

19.7.10 Insulating oil

Insulating oil used in transformers shall be an organic oil type complying with IEC 61099 and shall be readily available in Australia.

The use of insulating oil containing polychlorobiphenyls (PCBs) is strictly prohibited.

In maintenance instructions, contractors shall include procedures for periodic sampling of insulating oil for laboratory analysis. Allowable ranges of dielectric strength, oil impurities and any other indications of oil and/or winding breakdown shall be provided. Corrective procedures for each type of problem able to be identified by periodic oil analysis shall be provided.

19.7.11 Kiosks

Each kiosk shall incorporate the following features:

- designed so that arc flash from internal switchgear or cable failure is vented away from persons standing in front of the switchgear with the doors open
- concrete plinths may be required to be designed and constructed with a chamber that can disperse heated gas
- weatherproof enclosure
- hot-dipped galvanized mild steel, fully welded skid base complete with lifting facilities
- grouted between the skid and concrete pad
- peaked roof to shed rainwater
- integral internal oil bund, with a capacity of at least 100% of the oil volume of the transformer
- ventilation louvres, stainless steel or aluminium – louvres into the kiosk-end compartments shall have stainless steel mesh type insect barrier installed
- cable penetrations between compartments shall be sealed to prevent the ingress of vermin

Warning – this document is current at time of printing or downloading. It may be reviewed and amended prior to the noted review date at the discretion of Hunter Water Corporation.
• hinged lockable doors (three-point locking mechanism) at each end and side access points – providing access to off load tap changer selector switch, all protection and indication devices, all valves, CTs, etc.

• lockable doors shall be fitted with standard lock barrels to the principal’s keying standards

• stainless steel door handles and fittings, including saddles, bolts, screws and other fixtures

• transformer junction box (refer to 19.7.12 Transformer junction boxes) located inside the LV end of the kiosk

• cable clamps and adjustable cable support frames, e.g. ‘Unistrut’, for HV and LV cables

• tinned copper earth bar (6 x 40mm minimum size) inside the LV end of the enclosure, complete with stand-off stud insulators, predrilled with not less than twelve (12) 14mm diameter holes to suit M12 bolts

• earth bonds (i.e. green/yellow PVC insulated cable) to the earth bar for kiosk, transformer tank, all doors, etc., as per AS/NZS 3000

• surface preparation and paint system as specified for transformers in 19.7.6 External surface treatment and painting

• nameplate (referred to in 19.7.14 Nameplates) located on the outside of the kiosk

• rating plate (referred to in 19.7.15 Rating plates) located on the transformer inside the kiosk

Contractors shall confirm kiosk enclosures do not invalidate the temperature rise type test (refer to 19.9.1 Type testing).

Where there is a requirement in the system design for a transformer kiosk substation, the following equipment shall also be installed:

• HV ring main unit

• LV ACB (withdrawable)

• all interconnections (e.g. cabling/Busbar) between transformer and HV ring main unit and LV CB distribution board

The LV CB switchboard shall be classed as an external switchboard and shall be designed and constructed in accordance with 16 Switchboards.

19.7.12 Transformer junction boxes

Junction boxes shall be provided on each transformer for marshalling wiring from the transformer protection devices, including CTs installed on transformers.

Junction boxes shall be readily accessible and inside the LV end of the kiosk enclosure.

Junction boxes shall have a degree of protection of IP56 (minimum) and shall have bottom cable entry.

Wiring within junction boxes shall comply with 20 Cables and wiring.

All terminals shall be uniquely numbered in accordance with the respective schematic diagrams.

19.7.13 Transformer wiring

All conductors shall be stranded copper with V75 PVC 0.6/1kV insulation minimum.
All cables between transformer junction boxes and all transformer-mounted devices (e.g. protection devices) shall be installed in flexible metal conduits with grey PVC serving. The ends of all such flexible metal conduits shall be fitted with glands or bushings.

All cabling and wiring shall comply with 20.5 Reticulation wiring.

19.7.14 Nameplates

A large identifying nameplate shall be attached to each transformer. Nameplates shall have aluminium backing with PVC printing.

Nameplates shall be placed in a prominent position so to be clearly visible from the front of each transformer, and the outside of kiosk enclosure.

Nameplates shall display the following information: text size, colour
Transformer identification number and description: 80mm high, black
Voltage ratings of primary and secondary winding: 50mm high, black
Transformer rating: 50mm high, black
Oil type: 25mm high, black

19.7.15 Rating plates

A stainless steel rating plate shall be attached to each transformer.

Rating plates shall be placed in positions that are clearly visible from the front of transformers (and inside kiosk enclosures).

All information required by AS/NZS 60076.1 and oil type shall be included on each rating plate.

19.8 Technical requirements

Transformers shall also comply with the following design requirements:

<table>
<thead>
<tr>
<th>Ref</th>
<th>Rating or feature</th>
<th>1.5 to 3 MVA pad mount</th>
<th>315kVA to 2.5 MVA pad mount kiosk</th>
<th>Pole mount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Zero phase sequence impedance at MCR</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
</tr>
<tr>
<td>2</td>
<td>Transient reactance</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
</tr>
<tr>
<td>3</td>
<td>Oil temperature rise at MCR</td>
<td>( \leq 58^\circ\text{K rise over 50}^\circ\text{C maximum ambient} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Winding temperature rise at MCR</td>
<td>( \leq 63^\circ\text{K rise over 50}^\circ\text{C maximum ambient} )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ref</td>
<td>Rating or feature</td>
<td>1.5 to 3 MVA pad mount</td>
<td>315kVA to 2.5 MVA pad mount kiosk</td>
<td>Pole mount</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------</td>
<td>------------------------</td>
<td>----------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>5</td>
<td>Reference temperature (Tref)</td>
<td>75°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Guaranteed losses at Tref = 75°C &amp; 100% MCR</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
</tr>
<tr>
<td>7</td>
<td>Efficiency at PF = 1.0 at 25%, 50%, 75% and 100% of MCR</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
</tr>
<tr>
<td>8</td>
<td>Sound power level at MCR</td>
<td>‘Standard limit’ Annex ZA of AS 60076.10</td>
<td>‘Standard limit’ Annex ZA of AS 60076.10</td>
<td>‘Standard limit’ Annex ZA of AS 60076.10</td>
</tr>
<tr>
<td>9</td>
<td>Connections on HV side Note 1</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
</tr>
<tr>
<td>10</td>
<td>Connections on LV side Note 1</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
<td>TBA by contractor</td>
</tr>
</tbody>
</table>

Note 1: Cable types, sizes and quantities TBA by the Contractor after detailed design.

### 19.8.1 Losses

Transformers shall be designed in accordance with modern low-loss practices incorporating standard features commensurate with distribution transformers of a similar size.

### 19.9 Testing

### 19.9.1 Type testing

**Impulse test (type test)**

Contractors shall provide an impulse test (type test) report as per AS/NZS 60076.4 for each type of transformer.

Previous impulse type test reports may be presented if the equipment previously tested is identical or similar to the designs for the site. All differences between type tested designs and designs for the site shall be supported by calculations and/or explanations to demonstrate the equipment complies with specified requirements.

Alternatively, new impulse type tests may be performed on one of each type of transformer.
Temperature rise test (type test)

Contractors shall provide a temperature rise test (type test) report as per AS/NZS 60076.2 for each type of transformer.

Previous temperature rise test reports may be presented if the equipment previously tested is identical or similar to the principal’s designs. All differences between type tested designs and the designs shall be supported by calculations and/or explanations to demonstrate the equipment complies with specified requirements.

Alternatively, new temperature rise type tests may be performed on one of each type of the transformers.

Contractors shall provide evidence that kiosk enclosures described in 19.6 Special requirements for coastal and harsh environments do not invalidate the temperature rise type test.

Sound pressure test (special test)

Contractors shall provide a sound pressure test (special test) report as per AS/NZS 60076.10 for each type of transformer.

Previous sound level test reports may be presented if the equipment previously tested is identical or similar to the designs for the project. All differences between type tested designs and the designs shall be supported by calculations and/or explanations to demonstrate that the equipment complies with specified requirements.

Alternatively, new sound level tests may be performed on one of each type of transformer.

Short circuit test for transformers

Contractors shall provide a short circuit test report as per AS/NZS 60076.5 for each type of transformer.

Previous short circuit test reports may be presented if the equipment previously tested is identical or similar to the designs. All differences between type tested designs and the designs shall be supported by calculations and/or explanations to demonstrate that the equipment complies with specified requirements.

Alternatively, new short circuit tests may be performed on one of each type of transformer.

Alternatively, if short circuit strength is demonstrated by calculation, then such calculations shall consider relevant factors such as:

- peak asymmetrical short circuit current
- peak asymmetrical ampere turns
- ability to withstand thermal effects of short circuits
- ability to withstand peak hoop stresses on the HV windings
- ability to withstand peak hoop stresses on the LV windings
- ability to withstand peak internal axial compression
- ability to withstand peak unbalanced axial forces
- ability to withstand peak tensile stress on tie rods
All such calculations shall take into consideration the principal’s specified requirements and be fully documented in a written report.

**General**

If a new type or special tests are performed, representatives from the principal shall be given the opportunity to witness the tests. Fourteen (14) calendar days’ notice shall be given for tests in Australia and twenty-one (21) calendar days’ notice shall be given for tests outside Australia.

Copies of all type test reports, whether previous or new, shall be submitted to the principal for approval.

**19.9.2 Factory acceptance testing**

All routine tests listed by AS/NZS 60076.1 – 10 shall be performed on each transformer at the transformer factory prior to shipment to site, including:

- measurement of voltage ratio and vector group relationship
- measurement of winding resistance (11kV and 415V windings)
- measurement of impedance voltage
- measurement of load losses
- measurement of no-load losses
- insulation resistance tests
- dielectric tests
- separate source power frequency test
- separate source power frequency test (LV to HV and earth for one minute)
- induced over-voltage withstand test
- calculated load losses at 25%, 50%, 75% and 100% of MCR with correction to Tref = 75°C

Factory acceptance tests shall also include:

- detailed mechanical inspection
- detailed electrical inspection
- functional testing of all protective devices, where possible
- review of routine test certificates for protection devices from place of manufacture
- review of routine test certificates and magnetization curves for CTs from place of manufacture
- review of manufacturing inspection and test documentation and records
- review of manufacturing defect lists/punch lists

Representatives from the principal shall be given the opportunity to witness factory acceptance tests. Fourteen (14) calendar days’ notice shall be given for tests in Australia and twenty one (21) calendar days’ notice shall be given for tests outside Australia.

The results of all factory acceptance tests shall be available for review during the tests.
A comprehensive factory acceptance test report shall be submitted for review within five (5) working days of completion of the tests, or prior to shipment, whichever is earlier. Factory acceptance test reports shall include:

- results of all tests
- copies of any test oscillograms, graphs, printouts, and the like
- copies of all routine test certificates from place of manufacture for protection devices, CTs, etc.
- copies of magnetisation curves for all CTs
- copies of manufacturing inspection and test documentation and records, follower cards, etc.
- copies of factory defect lists/punch lists
- copies of completed factory ITPs
- statements confirming compliance with specified requirements

All defects arising prior to or during factory acceptance tests shall be rectified to the satisfaction of Hunter Water prior to the respective transformer being shipped to site.

19.9.3 Site testing

Contractors shall provide a detailed procedure to be reviewed by Hunter Water for site testing and commissioning of transformers. The procedure shall fully comply with the requirements of AS/NZS 3000.

Site tests will be performed by contractors, in accordance with the provided procedures.

Contractors shall perform dissolved gas analyses, complete with oil quality data (moisture, moisture corrected to 20°C, total acidity, IFT and electric strength) upon transformers arriving on site, and one month after energisation.

19.10 Access

Hardstand areas shall be constructed around substations that shall enable vehicle access and appropriately sized cranes in all weather conditions.

19.11 Long-term maintenance/strategic spare parts and special tools

Contractors shall provide lists of recommended spare parts for long-term maintenance activities and strategic planning, as well as any special tools required to perform long-term maintenance activities. Suitable packing requirements for long-term storage shall be recommended.
20 Cables and wiring

20.1 General

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’.

Wiring shall be distinctive colours and coded, as detailed in 16.6.2 Wiring identification colours.

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

20.2 Cable identification

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

Identifying cable tags shall be 316 stainless steel and attached using stainless steel 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.

20.2.1 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.

For pumping stations the cables shall be identified with a suffix representing the cable number, i.e. C* for control cables.

Examples of cable types:

<table>
<thead>
<tr>
<th>P</th>
<th>Consumers mains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sub mains</td>
</tr>
<tr>
<td></td>
<td>Final sub circuits</td>
</tr>
<tr>
<td></td>
<td>Device power supplies (any voltage)</td>
</tr>
<tr>
<td></td>
<td>Motor cables</td>
</tr>
<tr>
<td></td>
<td>Motor cables with pilot cores</td>
</tr>
</tbody>
</table>
## 20.2.2 Wire numbering

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

## 20.3 Wiring to equipment

Connecting wiring to equipment shall not compromise the IP rating of the equipment being connected.

Wiring to permanently connected equipment which vibrates or may be moved for adjustment shall have multi-stranded flexible conductors protected by flexible conduits of length to suit the application. The conductors shall be protected by PVC-coated steel or PVC flexible conduit to suit the particular installation. Conduits shall terminate not more than 15mm prior to entering equipment and cable, then enter the equipment through cable glands. 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.

## 20.3.1 Final subcircuit wiring and Field control cabling

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

<table>
<thead>
<tr>
<th>Circuit Type</th>
<th>Minimum Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power circuits</td>
<td>2.5mm², copper conductors</td>
</tr>
<tr>
<td>Lighting circuits</td>
<td>1.5mm², copper conductors</td>
</tr>
<tr>
<td>Motor circuits</td>
<td>2.5mm², copper conductors</td>
</tr>
</tbody>
</table>

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Version 4 authorised by Lutz Backhausen on 05/03/2019
Control circuits  1.0mm², 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.

20.4 Cable specifications

20.4.1 Single cables in enclosures

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

20.4.2 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.

20.4.3 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.

20.4.4 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.
20.4.5 High voltage insulated cables

Insulated high voltage cables shall be screened.

20.4.6 Aerial cables

Low voltage cables shall be insulated.

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.

20.4.7 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.

20.4.8 Telephone cables

Cables used for communication purpose shall be multi-pair telephone cables of nominal conductor diameter 0.4mm², minimum to Telstra and/or AS/ACIF specifications.

20.4.9 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 1.5mm² 250V grade stranded copper cable and shall have red sheathing.

20.4.10 Security cables

Cables used for window and door seals, and associated equipment shall be minimum 0.5mm² stranded copper cable.

Cables for space detectors (ultrasonic, infra-red, microwave, etc.) shall be minimum 0.5mm² stranded copper shielded twisted pairs or as per manufacturers’ installation requirements.

20.4.11 Variable speed drives (VSD) and soft start (SS) motor cables

Cables and cable glands used for VSD and SS 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.
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. The cable shall consist of pairs of seven strands of minimum size 1.5mm².

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.

20.4.12 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 together 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.

20.4.13 Optical fibre cables

All new fixed cabling between communications cabinets or floor distribution closets shall be optical fibre, in multimode up to 500m, and 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. switch, router, etc. The cables shall contain a minimum of 12 cores and all cores shall be terminated to patch panels at both ends – SC connections for OM1, and LC connections for OM3. SCADA and control networks shall not share the same physical optical fibre cables.

In all cases, there shall be a minimum of two 'spare' optical fibre cores in each cable run after the installation is complete.

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 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.

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 trodden on while anyone is working in that pit.

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’.

Patch panels for 19-inch racks shall be withdrawable cassette tray types with 20% spare capacity.
ITPs

Test fibres with an optical fibre tester, with results that confirm successful test outcomes. Results shall be submitted in both written and electronic format.

20.4.14 Copper Ethernet cables

(a) CAT 5e/6 cable is to be used in the communications cubicle

(b) 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.

(c) CAT 5e/6 cable is not to be used between buildings/plant areas that have separate earthing connections. In general, optical fibre cables shall be used between buildings and plant.

(d) All cables shall be terminated at both ends to either patch panels or telecommunications outlets (UTP/STP). There shall be one spare telecommunications outlet per physical destination, so 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.

(e) All cables and terminations are to be clearly labelled at both ends to facilitate identification.

(f) 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.

(g) The maximum length of any patch lead is not to exceed 5m and shall be factory certified, flexible, and green in colour.

(h) If control is carried out over Ethernet (e.g. VSD, IMCC, etc.), each device must be connected to a separate port on the control network switch/router. Daisy-chaining of Ethernet-enabled devices is not permitted.

ITPs

Test fixed cables with a network cable tester, with results that confirm successful test outcomes. Results shall be submitted in both written and electronic format.

Where an ‘Ethernet cross-over cable is required, it shall always be red in colour, regardless of its use.

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.
20.5 Reticulation wiring

20.5.1 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.

20.5.2 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. 24V DC, 240V AC.

Segregate data and power cabling in accordance with the requirements of the table shown below.

### Separation between power and data cables

<table>
<thead>
<tr>
<th>Circuit rating (kVA)</th>
<th>Unshielded power cables</th>
<th>Shielded power cables</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤1</td>
<td>300mm</td>
<td>25mm</td>
</tr>
<tr>
<td>&gt;1 ≤2</td>
<td>450mm</td>
<td>50mm</td>
</tr>
<tr>
<td>&gt;2 ≤5</td>
<td>600mm</td>
<td>150mm</td>
</tr>
<tr>
<td>&gt;5</td>
<td>1500mm</td>
<td>300mm</td>
</tr>
</tbody>
</table>

20.5.3 Mechanical protection

Supply and install mechanical protection on all cables, cable ladders, conduits and electrical equipment under the following, but not limited to:

- for a distance of 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 of electrical equipment shall be constructed to withstand the shock loading likely to occur in the area. Covers, when used outdoors, shall be constructed of minimum 5mm aluminium.

Sheet metal covers installed to provide mechanical protection of electrical equipment shall be constructed to enclose the equipment and associated conduits. The covers shall be 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.

20.5.4 Underground reticulation

20.5.4.1 General

All cables to be run underground shall be enclosed in conduits.

Conduits shall not run lengthwise under roads. Where they cross roads they shall be at 90° to the roadway.

Cables throughout the site shall be segregated into conduits allocated to the following groups:

- HV power
- LV power
- 24V DC control cables, thermistor cables, instrumentation cables, potentiometer cables, PLC data cables, etc.

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.

Submit plans and schedules of the size, route, distance, and depth of all underground cables and conduits. Do not order cables nor commence excavation work before a confirmation of conformity to the design submission is received.

20.5.4.2 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.
20.5.4.3 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.

20.5.4.4 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 150mm below finished ground level 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 the original 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.

20.5.4.5 Underground cable protection

Where additional cable protection is required it shall be polymeric type. Marker tape shall be a minimum of 150mm wide.

20.5.4.6 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
- 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 concrete-walled to prevent ingress of water, and all conduits shall enter pits from the side. For single-conduit runs, moulded PVC pits can be used following approval from Hunter Water.

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 a distance of 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%. Cables shall enter and exit HV pits on the diagonal to allow the maximum use of space within the pit.

Conduits which enter or exit pits shall be fitted with bell mouths formed into the walls of the pit.

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 particular loading conditions.

<table>
<thead>
<tr>
<th>Class</th>
<th>Typical use</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>Areas where there is no access by vehicles, e.g. grassed areas, gardens, etc.</td>
</tr>
<tr>
<td>C</td>
<td>Areas where there is access to slow moving light commercial vehicles only.</td>
</tr>
<tr>
<td>D</td>
<td>Areas where all vehicles can access.</td>
</tr>
</tbody>
</table>

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.

**20.5.4.7 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
- at a maximum 10m spacing for straight runs
Marking plates shall be made of minimum 1mm thick brass, 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.

### 20.5.4.8 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.

### 20.5.4.9 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.

### 20.5.5 Conduits, fittings and joints

#### 20.5.5.1 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.

#### 20.5.5.2 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.
20.5.5.3 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.

20.5.5.4 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.

20.5.5.5 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°. 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.

20.5.5.6 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° 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.
20.5.5.7 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.

20.5.5.8 Telephone conduits and cabling

Underground conduits shall be heavy-duty PVC type, coloured white, and spaced from other services, as per AS/ACIF S009.

20.5.6 Cable protection and support

20.5.6.1 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.

20.5.6.2 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. Do not use self-tapping or self-drilling screws.

The ducts shall be adequately supported in accordance with the manufacturers’ recommendations and load tables.

20.5.6.2.1 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 grade 5251-H34, 316 stainless steel, and PVC.

20.5.6.3 Cable trays and ladders

20.5.6.3.1 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

Where possible, 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. Where using similar metals is not possible or practical, insulating barriers may, at the principal’s discretion, be installed.

Metal cables tray and ladders shall be earthed along their entire lengths, using an AS/NZS 3000-compliant earth wire connected directly to the earth bar.

### 20.5.6.3.2 Perforated cable trays

Perforated cable trays shall be manufactured from aluminium.

### 20.5.6.3.3 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.

### 20.5.6.3.4 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, unless absolutely necessary. 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 – for vertical runs at 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.

### 20.5.6.4 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.

### 20.5.7 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

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Do not use expanding foam for sealing penetrations.
Do not construct penetrations through damp courses.

20.6 LV, HV and control cable tests

Inspect for damage.

Carry out insulation resistance tests on all cables. The final insulation resistance test shall be carried out after terminations are completed.

Control cables shall be insulation resistance tested between earth and each core and between cores.

Insulation tests shall be as per manufacturers’ recommendations for insulation type and operating voltage.

Check the installed cable size complies with the requirements of *AS/NZS 3008.1, AS/NZS 3000* and the *Service and Installation Rules of New South Wales*. 
21 General equipment

21.1 ITPs

ITPs shall include:

- operation of all alarms and trips, to be displayed in HMI and SCADA
- correct display of all required monitoring points in HMI and SCADA

21.2 General

21.2.1 Durability of materials

Use UV-resistant materials where exposed to sunlight or other UV light.

21.2.2 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.

21.2.3 Mounting of equipment

Mount any equipment which needs to be operated or maintained a minimum of 300mm above the finished floor level.

21.2.4 Labelling of equipment

All equipment shall be labelled to reflect the tag identifier of the device.

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

21.3 Motors

21.3.1 FAT

21.3.1.1 Test records

Test records shall clearly describe the details of the tests and the results. All calculations shall be provided. Any remedial actions taken following testing shall be recorded.

Provide a motor torque/speed/efficiency characteristic curve, along with a motor test curve.

Other records shall include at least the following information:

- motor nameplate details
- relevant drawing numbers
• insulation resistance test results
• winding resistance value, with cabling disconnected
• name of person conducting tests, date of testing and project name
• any remedial action

Motors for which type test certificates are not available shall be performance tested at manufacturers’ works in accordance with AS 60034.1. Performance tests shall be carried out on the motor only, not as part of an integral motor/pump unit.

Contractors shall submit three (3) certified copies of test reports on completion of final factory acceptance tests.

21.3.1.2 Type tests

Documentation shall be submitted on delivery, indicating that all type tests required by AS 1359 have been performed satisfactorily on each motor, or on a motor of an identical design.

21.3.1.3 Noise level tests

Documentation shall be submitted on delivery, indicating that noise level tests in accordance with AS 60034.9 and AS 1081 have been carried out satisfactorily on each motor, or on a motor of an identical design.

21.3.1.4 Routine tests

Documentation shall be submitted on delivery, indicating that routine factory acceptance testing in accordance with the requirements of AS 1359 have been carried out satisfactorily on each motor.

21.3.2 General

Motors shall be of the premium high-efficiency type. They shall be equivalent to 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.

21.3.3 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.

21.3.4 Anti-condensation heaters

Anti-condensation heaters shall be fitted to keep the motor 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’.

21.3.5 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 top coat
- final colour Munsell 5PB3/8 blue

21.3.6 Noise

Noise levels are to be as per AS 60034.9, AS 1081 and this STS.

21.3.7 Bearings

Bearings shall conform to specifications listed in STS 600 - General Mechanical Requirements.

21.3.8 Temperature detection

All motors shall have thermistors imbedded in the hottest part of the motor. The thermistors shall be wired in series and the end leads brought out to terminals in a terminal box on the stator frame.
Motors greater than 22kW 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.

Motors greater than 22kW shall be provided with 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.

### 21.3.9 Vibration detection

Where specified, larger motors 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.

### 21.3.10 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.

### 21.3.11 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°C by resistance method, in an ambient temperature of 40°C (Class E).

### 21.3.12 Motor ratings

The selected size and rating of electric motors shall take into account transient conditions, including starting, braking, reversing, load and speed variations, load torque requirements and motor speed-torque characteristics.
The rating selection shall also take into account 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.

21.3.13 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.

21.4 Switches and outlets

21.4.1 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.

21.4.2 Wall-mounted switches

21.4.2.1 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.

21.4.2.2 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.
21.4.3 240V 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.

21.4.4 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.

21.4.5 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.

21.4.6 ELV power socket outlet

ELV power socket outlets shall comprise two flat pins at right angles for DC, and flat parallel pins for AC.

21.4.7 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.

21.5 Luminaires

21.5.1 General

All lights shall be high energy efficiency 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.

21.5.2 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.

21.5.3 Lamps

Unless otherwise indicated:

- fluorescent tubes shall only be used for indoor locations below a height of three metres
- all other lamps shall be metal halide or as specified in Hunter Water’s approved electrical products list

21.5.4 Recessed luminaires

Recessed luminaires shall be fitted with flexible cords with minimum 0.75mm² 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.

21.5.5 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.

21.5.6 Dry well sewage pumping stations

All lights below switchboard level shall be IP65 rating and shall be individually wired back to the switchboard.
22 Packaged plants

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.
23 Security system

Design security systems as per STS 105 – Security at Hunter Water Corporation Assets.

Exceptions apply for hazardous areas.
## 24 Document control

**Document controller:** Group Manager Capability Engineering

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<td>March 2019</td>
<td>R Watson</td>
<td>General review of all sections, inclusive of formatting.</td>
<td>5 March 2019</td>
<td>L Backhausen</td>
<td>March 2021</td>
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# 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.

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