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Foreword

This Specification is for the design, supply and installation of mechanical works for Sydney Water Corporation assets.

Sydney Water makes no warranties, express or implied, that compliance with the contents of this Specification shall be sufficient to ensure safe systems or work or operation.

It is the user’s sole responsibility to ensure that the copy of the Specification is the current version as in use by Sydney Water.

Sydney Water accepts no liability whatsoever in relation to the use of this Specification by any party, and Sydney Water excludes any liability which arises in any manner by the use of this Specification.

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E1 General

- For the purpose of this specification “Sydney Water” or “SWC” is the nominated person or organisation that has written authority and act on Sydney Water Corporation’s behalf.
- Equivalent alternative design, materials and construction methodology may be used if accepted by SWC.
- The content of this specification must not be changed without notifying the custodian of this document.
- This Specification is not intended to be a stand-alone document. Project specific documents and additional technical clauses may apply and must be considered.

E1.1 Scope

This specification sets out the minimum requirements for the design, supply, installation, and construction of electrical equipment and installations in Sydney Water projects.

Refer to the Civil and Mechanical specifications for the civil and mechanical requirements.

The specification does not include instrumentation and control equipment, which are covered in the "Instrumentation and Control Standards Manual" and "Treatment Plant SCADA Standards".

This specification does not include IICATS (Integrated Instrumentation, Control, Automation and Telemetry System) interface requirements for Sydney Water’s water and wastewater network assets. The definition of ‘Signals for SCADA’ in this specification is used only for water and wastewater treatment plants SCADA systems. The following specific instrumentation and control standards shall be used for IICATS interface and design of water and wastewater network assets:

- Instrumentation and Control Standards (General) TOG_TS01
- Water Distribution System related Instrumentation and Control Standards TOG_TS02
- Sewage Pumping Station related Instrumentation and Control Standards
- Pumpstation electrical template drawings
- Deemed to Comply (DTC) drawings, if available.

For the design of sewage pumping stations, the work shall comply with this specification and the Sydney Water edition of the Sewage Pumping Station Code of Australia and any Standard Drawing Templates issued with the project.

High voltage equipment is covered under separate specifications. Please refer to Clause 5 for a list of HV and related equipment specifications which can be downloaded from the SWC’s internal website. However, the selection of equipment’s shall consider the applicability of alternative designs.

The requirements are intended to provide a guideline to build electrical infrastructure to fulfil Sydney Water’s obligation to protect health and the environment in the most cost effective and safe manner. They are not intended to restrict designs or choice of equipment. Alternative design and equipment specified shall not be inferior in performance and lifecycle costs to existing assets that are performing reliably. Refer to the Urban Design and Engineering team in Liveable City Solutions for advice.

Where conflicts exist between this specification and any statutory requirement (e.g. the Work Health and Safety Act and Regulations), the statutory requirement prevails.

Where conflict exists between this specification and any other nominated Contract document, SWC must be notified in writing to nominate which will take precedence.
## E1.1 Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC</td>
<td>alternating current</td>
</tr>
<tr>
<td>AS/NZS</td>
<td>Australian Standard/ New Zealand Standard</td>
</tr>
<tr>
<td>CT</td>
<td>current transformer</td>
</tr>
<tr>
<td>DC</td>
<td>direct current</td>
</tr>
<tr>
<td>ELV</td>
<td>Extra-low voltage: Not exceeding 50 V a.c. or 120V ripple-free d.c.</td>
</tr>
<tr>
<td>EMC</td>
<td>electromagnetic compatibility</td>
</tr>
<tr>
<td>HV</td>
<td>Exceed low voltage</td>
</tr>
<tr>
<td>I&amp;C</td>
<td>instrumentation and control</td>
</tr>
<tr>
<td>IDMT</td>
<td>inverse definite minimum time (protection)</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission (Standard)</td>
</tr>
<tr>
<td>IICATS</td>
<td>integrated instrumentation, control, automation and telemetry system</td>
</tr>
<tr>
<td>LD, HD</td>
<td>light duty, heavy duty (conduits)</td>
</tr>
<tr>
<td>LV</td>
<td>Exceed Extra-low voltage, but not exceeding 1000 V a.c. or 1500 V d.c.</td>
</tr>
<tr>
<td>MCC</td>
<td>motor control centre</td>
</tr>
<tr>
<td>N/O, N/C</td>
<td>normally open, normally closed (contacts)</td>
</tr>
<tr>
<td>PVC</td>
<td>polyvinyl chloride</td>
</tr>
<tr>
<td>PTC</td>
<td>positive temperature coefficient (thermistors)</td>
</tr>
<tr>
<td>RMU</td>
<td>ring main unit</td>
</tr>
<tr>
<td>RTD</td>
<td>resistance temperature detector</td>
</tr>
<tr>
<td>SCA</td>
<td>switchgear and control gear assembly</td>
</tr>
<tr>
<td>SCADA</td>
<td>supervisory control and data acquisition</td>
</tr>
<tr>
<td>SCR</td>
<td>silicon-controlled rectifier</td>
</tr>
<tr>
<td>SPS</td>
<td>sewage pumping station</td>
</tr>
<tr>
<td>STP</td>
<td>sewage treatment plant</td>
</tr>
<tr>
<td>UPS</td>
<td>uninterruptible power supply</td>
</tr>
<tr>
<td>VSD</td>
<td>variable speed drive</td>
</tr>
<tr>
<td>VT</td>
<td>voltage transformer</td>
</tr>
</tbody>
</table>
### Technical Specification Electrical

<table>
<thead>
<tr>
<th>WFP</th>
<th>water filtration plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>WPS</td>
<td>water pumping station</td>
</tr>
</tbody>
</table>

#### E1.2 Compliance with Authorities and Standards

All work performed, equipment supplied and modifications carried out to the existing equipment shall comply with the appropriate latest issues of Australian Standard or, in their absence, the latest IEC Standards.

Except where the specification requires a higher standard, all work shall be carried out in accordance with the latest edition of AS/NZS 3000 *(SAA Wiring Rules)*, AS/NZS 3008.1.1, the services rules of the electricity distributor, and all relevant statutory authorities. Electrical installations operating at high voltage and earthing shall be designed and installed in accordance with AS 2067.

All work shall be of the best quality incorporating the best means of providing and installing all equipment including cables. All work shall be subject to the inspection and approval of the electricity distributor.

Proof of compliance with a standard or specified test may be required. Where requested, such proof shall comprise a test certificate from an independent testing authority.

All design work shall comply with Australian Standards and codes as stated in this specification or other parts of the Contract Document. If no such Standard or code is nominated, the Works shall comply with the most relevant Australian Standards and codes.

If an international or overseas standard or code is proposed in lieu of an Australian Standard, a detailed assessment to show that the proposed standard or code is equivalent to the relevant Australian standard or code must be submitted to SWC for acceptance.

If there is no Australian Standards or codes covering the subject, an international or overseas standard or code may be used if accepted by SWC.

Any design work proposing to connect a Sydney Water installation to the electrical network (i.e. Ausgrid and/or Endeavour Energy) must be performed by an appropriate NSW Accredited Service Provider (ASP).
E2 Design consideration

E2.1 Energy Minimisation

Plant and equipment shall be designed to minimise electrical energy consumption. This shall include but not be limited to the following measures, which shall be included in the design:

- Power factor correction (refer E2.6 and E10)
- Load balancing across phases
- Automatic control of lighting to reduce unnecessary lighting
- Use of LED lighting
- Correct sizing of electrical motors and devices
- Selection of high efficiency motors and electrical devices (refer E11)
- Design of processes to be efficient and to spread electrical energy consumption requirements over time to reduce peaks in electrical loads
- Efficiency of co-generation facility
- Minimising forced heating/cooling requirements for buildings by using insulation, careful selection of building aspect, careful placement and size of windows and effective removal of heat generated by equipment eg VSD
- Use of filters to reduce harmonics (refer E2.9 and E9.22.3)

E2.2 Reliability and Operation of Process Equipment

Concept design shall be prepared and risk assessment shall be carried out before proceeding to detail design of power supply and control system of all process equipment. Process equipment that are critical to plant operation shall be identified. Control and power supply to these critical processes shall be provided with adequate redundancy to ensure that plant performance standard is within operating licence requirements. Consideration shall be given to the use of uninterruptible power supply, standby generators and how equipment behave when power supply fails (e.g. valve fails to open or close position). Duty and standby equipment starters shall be supplied from separate sections of a switchboard. Failure of any single device shall not prevent operation of more than one process equipment. The plant shall be capable of being safely operated using field push buttons whenever there is any failure of automatic operation.

All starters and equipment related to a particular process shall be physically grouped together and supplied from the same switchboard. Switchboards shall be installed in the switchroom allocated for the respective process area.

When multiple supplies including standby generator supplies are required for one switchboard, the design shall ensure each incoming supply switch is housed in an independent switchgear panel. The layout and configuration must be designed to minimise the potential risk of live work being carried out. Performing maintenance work on the standby generator switch shall not affect the availability of at least one permanent incoming supply. If there are more than one permanent incoming supplies on the switchboard, perform maintenance work on one permanent incoming supply shall not need to use the standby generator to supply power.

E2.3 Standby Generator

Consideration shall be made to provide the manual connection of a standby or a permanent generator to operate during periods when electricity distributor power is not available. The installation of standby or a permanent generator shall be in accordance to AS/NZS 3010. Both the main incoming and the standby generator circuit breakers shall be mechanically interlocked as per AS 3010 so that only one (1) of them...
could be ON at any time. A combined phase sequence and rotation meter shall be installed on the standby generator isolator panel on the switchboard. The meter must be connected on the bus side of the isolator.

A generator connection panel shall be provided on the outside wall of the switchroom to enable the switchboard to accept power from a mobile emergency generator. The panel shall be stainless steel with padlock facility. The panel shall be fitted with clear/colourless, flat non-conductive IP2X shielding to prevent personnel from coming in contact with live terminals. The mobile generator set cable entry is to be through the bottom of the panel. The panel door must be able to be closed and padlocked with the mobile generator set cable connected. The panel shall be adequately sized to allow for cable bending radius to be accommodated.

Hardstand for the generator(s) must be provided to enable the connection of the generator(s) to the connection panel without causing a safety hazard.

The location for the mobile generator set shall be located close to the generator connection panel. Consideration shall be given for vehicle access for setup and refuel the generator.

**E2.4 Minimisation of Hazardous Areas and Confined Spaces**

Installations shall be designed to minimise the number of areas classified as flammable gas hazardous areas under the current Australian Standard.

Installations shall be designed to minimise the number of areas classified as confined spaces under the Work Health and Safety Act.

**E2.5 Hazardous Areas**

The design must consider minimising the amount of equipment to be installed in a hazardous area.

The classification of the area shall be performed as required in AS60079 and as specified in TG0502 – Classification and management of flammable gas hazardous areas.

Equipment shall be IECEx or ANZEx certified only, no other certification schemes shall be accepted.

The preferred protection techniques for equipment are outlined in the table below:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Preferred Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zone 1</td>
</tr>
<tr>
<td>LV Motors</td>
<td>Ex d</td>
</tr>
<tr>
<td>Local Control Stations</td>
<td>Ex ed</td>
</tr>
<tr>
<td>HID Luminaries</td>
<td>Ex de</td>
</tr>
<tr>
<td>Fluorescent Luminaries</td>
<td>Ex e</td>
</tr>
<tr>
<td>Transmitters (4-20mA)</td>
<td>Ex i</td>
</tr>
<tr>
<td>I/P Converters</td>
<td>Ex i</td>
</tr>
</tbody>
</table>
Changes to the dossier and classification (including the addition of new zones or equipment) shall require the updating of the existing dossier. The production of a project specific dossier is not permitted.

Only competent personnel shall be used for the design and installation of all equipment in a hazardous area. Documentation shall be submitted to SWC satisfaction to confirm the personnel has been deemed competent. This documentation shall form part of the hazardous area dossier.

The assumed maximum ambient temperature is 45°C. All explosion-protected equipment shall be certified for a \( T_{amb} \) of at least 45°C. Written acceptance from the hazardous area committee shall be obtained prior to using equipment not certified for a \( T_{amb} \) of at least 45°C.

To reduce the effect of solar radiation, all electrical equipment shall be protected from direct exposure to solar radiation by location, sunshields, etc. unless its \( T_{amb} \) rating is at least 70°C, or a specific assessment deems that the equipment is suitable. Additionally, electrical equipment should be located away from heat from process equipment when this can cause excessive temperatures.

All documentation required to update the Hazardous Area Verification Dossier as required in TG0502 shall be submitted.

PVC glands shall not be installed in hazardous areas.

For network assets, the IICATS signals shall be provided as per IICATS standard.

### E2.6 Power Factor Correction

The installation power factor shall be a minimum of 0.95 lagging during normal operation. A power factor correction unit (s) shall be installed if the minimum power factor requirement cannot be achieved at site. The location and size of the power factor correction equipment shall be decided taking into consideration the loading of each area and energy minimisation. The power factor correction unit shall comply with the latest IEC 61921. The installation shall comply with the requirement of relevant Australian Standards, NSW Service and Installation Rules the electricity distributor.

Refer to Section E17 for power factor correction report and study requirements.

### E2.7 Power system and reticulation

The size and location of substations and the topology of power reticulation shall be determined in relation to the load demand in different areas of the plant, taking into account current flow, voltage drop, motor starting requirement, economy of scale, security of supply and operational flexibility. Ring or parallel feeders shall take different routes as far as possible.

Duty, standby feeders, generator connection points, and bus ties must be provided with mechanical or key interlock to prevent them from parallel operation. All LV boards and SCAs that have the potential for parallel operation shall have mechanical or key interlock to prevent parallel operation.

All power system related modelling and design work shall be carried out by using SKM Powertools software compatible with clients’ system. As a minimum, the system modelling shall include Load Flow Analysis, Fault Level Calculations, Arc Flash Assessment, Protection Grading Co-ordination throughout the new design and the existing system which impacted by the new design. Load-centres power distribution
principles shall be adhered to in both high voltage and low voltage power distribution systems design and installation.

Assessment reports for Load Flow Analysis, Fault Level Study, Arc Flash Assessment and Protection Coordinations shall be provided at the concept design based on the system modelling documenting the potential risk for the new design and existing system impacted by the new design, the assessment report shall also provide engineering mitigate methods to SWC for acceptance. The feedback from SWC shall form part of the input for further concept and detail design. Refer to Section 17 for details of system study report.

Electronic copy of the design and related documentations shall be submitted to Sydney Water. The system model and associated outputs shall remain the intellectual property of Sydney Water.

Load centres shall be established to ensure that no drive / motor / hand-station cable is longer than 150 m from their respective SCA / MCC.

The design of the power system and reticulation shall be submitted to SWC for acceptance. When required, the design must be made available to the relevant Supply Authority.

Where specified, remote operation of HV equipment shall be provided. These would include switching, racking and earthing. The remote operation shall be performed by a panel that is not located in the HV area.

High Voltage infrastructure should maintain a minimum of 15 metres from telephony and IICATS equipment.

**E2.8 Arc Flash**

Arc Flash Assessment shall be based on the latest IEEE 1584 and NFPA 70E standards, SCAs and MCCs have a rated nominal current equal or greater than 800A shall be assessed for Arc Flash risk through modelling, the contributions of Arc Flash model shall consider all energy sources including: Cogen system, diesel generator, solar system and etc., the motor load contributions for Arc Flash assessment shall consider all loads equal or greater than 37.5kW.

The Arc Flash Assessment report shall provide mitigation engineering options to reduce the arc flash risk when high incident energy level present in the new design and the existing system affected by the new design. The Arc Flash incident energy level of the final design must have prior agreement from SWC, and the risk reduction mitigation method must have prior acceptance from SWC before procuring equipment and implementation.

In addition to the System Study Report requirements in Section 17, the final Arc Flash Assessment report shall also provide

- Arc Flash labelling for each installation and area based on the assessment results showing:
  - Incident energy level at working distances (Cal/cm²), minimum working distance (mm) and PPE requirements (Category Number) for every possible work activity
  - Date of the Arc Flash assessment
  - Arc Flash boundary (mm)
  - Asset tag of the protection control device

- Arc Flash Single Line Diagram showing the electrical reticulation system with incident energy level colour coded at each bus.
- General Arrangement drawings in DWG format for each installation showing the Arc Flash boundaries.

**E2.9 Emergency Stops**

**E2.9.1 General**

Emergency stops shall, as a minimum, comply with AS/NZS 4024 and current NSW Work Health and Safety Act and regulations, in addition to any other regulatory or legislative requirement.
• Risk assessments shall be conducted and documented for all Sydney Water machines. Assessment templates and a detailed assessment procedure shall be produced by the designer.
• Maintenance requirements shall also be considered in the risk assessment. If elimination of the risk cannot be achieved, the designer should follow the hierarchy of controls (substitution, engineering controls, etc) to provide a safe outcome.
• Emergency stops shall not be used for isolation purposes.
• Emergency stops shall have hidden failure check process as recommended by the supplier
• If equipment is designed to be operated or attended by more than one person and more than one emergency stop is installed, the person with management or control of plant at the workplace must ensure all emergency stops are of the "stop and lock off "type so that plant cannot be restarted after emergency stop has been used unless all emergency stops are reset.
• The design of emergency stop controls shall employ Cat 4 safety circuit as per AS 4024, emergency stops shall not be adversely affected by electrical or electronic circuit malfunction
• The actuator of the emergency stop device shall be coloured RED, the background behind the actuator shall coloured yellow and placed as far away as practical from the actuator, the actuator of emergency stop shall be non-locking, with a large emergency stop label comprising black letters on a yellow background.
• Resetting of the emergency stop shall only be possible as the result of a manual action at the location where the emergency stop was activated.
• For Treatment Plant SCADA the circuits shall be based on Sydney Water template circuit TE100E and the requirements of the latest issue of Sydney Water Treatment Plant SCADA Standards.
• For all other assets, the circuit shall be in accordance with the latest issue of the Sydney Water I&C Manual and shall be accepted by Sydney Water.

E2.9.2 Latch Stop
Emergency stops that are not used for personnel safety shall be referred to as latch stops to aid distinction as to their function and avoid any confusion as to purpose with regard to the latest Work Health And Safety Act and regulations.
• They shall include a red mushroom head button against a grey background, pull to reset, non-locking, with no label.
• For Treatment Plant SCADA the circuits shall be based on Sydney Water template circuit TE100 and the requirements of the latest issue of Sydney Water Treatment Plant SCADA Standards.
• For all other assets, the circuit shall be in accordance with the latest issue of the Sydney Water I&C Manual and shall be accepted by Sydney Water. Where there is a conflict between this policy and relevant regulations or legislation, it is the responsibility of the designer to immediately notify Sydney Water upon becoming aware of such a conflict.

E2.10 Harmonics and Voltage Distortion in the Power Supply System
The power supply system and equipment shall not cause unduly severe voltage regulation and harmonic distortion on electricity distributor’s network. A Harmonic study must comply with requirements in Section 17. The level of harmonics shall comply with the Australian Standards and the requirements of the electricity distributor and shall comply with:

1. AS/NZS 61000: Parts 3.2, 3.4 and 3.12 - relates to harmonic currents.
2. AS/NZS 61000: Parts 3.3 and 3.5 - relates to voltage fluctuations and flicker.
3. AS/NZS 61000: Parts 3.6 and 3.7 - relates to assessment of emission limits for "distorting" and "fluctuating" load in power systems.
The design of the power supply system shall consider the impact of harmonics on the electricity distributor’s power network in the connection agreement. A harmonics study shall be carried out to identify the harmonics distortion imposed by the existing, modified and new equipment on the electricity distributor’s power network. The harmonics shall be measured and documented before and after the commissioning of new and/or modified equipment.

If required, additional equipment shall be installed to ensure compliance with the limits in the Standards and regulations and the requirements of the electricity distributor.

E2.11 Handstations and Interlocks

E2.11.1 Handstations

Each drive shall be fitted with a non-metallic handstation adjacent to it except where it has been demonstrated by risk assessment of that handstation is not required for an individual drive.

Each handstation shall incorporate individual pushbuttons mounted in an IP65 (weatherproof) GRP enclosure for the following functions as minimum:

- Start
- Stop
- Emergency or Latched Stop. Except where it has been demonstrated by risk assessment Emergency or latched stop is not required for a particular drive.

All drives that are not fitted with emergency stops shall be fitted with latched stops. The latched stops shall be distinguishable from emergency stops.

Emergency Stop / Latched Stop shall be wired directly into the drive control circuit in series with the main contactor. When activated the Emergency Stop / Latched Stop shall de-energise the circuit so that when re-activation is required a further step is involved other than pulling out the emergency stop / latched stop.

E2.11.2 Interlocks

As a minimum, the following interlocks shall be directly hardwired to the MCC starter panel to provide protection in Auto, Manual and Field modes. The interlocks shall include those specified in the Treatment Plant SCADA Standards and associated standard template drawings and schematic diagrams.

If the Treatment Plant SCADA Standards are not applicable the following interlocks shall be provided to the following listed (but not limited to) items:

1. All emergency stops as per AS4024 and the latest WH&S Regulation.
2. Thermal overload, thermistor and protection relay for motors.
4. Guard switches for screen, press, etc.
5. Pull wire switch and belt break switch for belt conveyor.
6. Electronic Shear pin switch for scrapers.
7. High pressure switch for compressors and blowers.
8. Oil and / or cooling water switch for large motors and / or pumps.
9. Fully open, fully closed and over-torque limit switches for valves and penstocks.
10. Starting siren and timer for belt conveyor.
11. Seal water flow switch for compressors and pumps.
13. Vibration monitoring – Alarms and trips (applicable to large equipment’s)
14. Motor liquid leakage sensors
15. No flow protection in WPS

E2.12 Instrument Transformers for Revenue Metering

For voltage transformers and current transformers used for the revenue metering purposes, design shall ensure they can be safely accessed for NATA certificate calibration and replacement. Test links or bars should be considered to facilitate instrument transformer testing and removing instrument transformers shall not cause major alterations to the equipment they are connected with. For a dual power supply facility, working instrument transformers on one power supply shall not need to isolate other power supplies to the site.

E2.13 Height Requirements

In accordance with AS 4024, Instruments, control switches, hand operated devices, and components that require to be seen and operated shall be installed with a centre line between 200 mm and 1680 mm from the floor. The centre line of all indication devices shall be mounted no taller than 1850 mm from the floor.

The design shall eliminate the need for a worker to access this equipment while adjacent equipment is energised and has the potential to cause electric shock due to unintentional inadvertent contact.

E2.14 Lifting Facilities

Refer to the Mechanical Specification Part 2 for all electrical component requirements when designing lifting facilities (e.g. jib cranes, monorail cranes, gantry cranes or other equipment).

E2.15 Spacing and segregation from other services

The spacing and segregation of electrical cable from other services must comply with the requirements in AS/NZS3000.

On Sydney Water sites, it is preferred for high voltage cables underground cables to maintain a minimum of 1,000mm from other services.

The design must consider other utilities that may be installed adjacent to Sydney Water property. Refer to the Sydney Water Build Over/Adjacent to Assets guideline for further information.

E2.16 RCD requirements for directly connected equipment

E2.16.1 Directly connected installations not requiring RCD protection

For the following directly connected installations, RCDs are not required:

1. Motor starters
2. Actuators
3. Ventilation/HVAC
4. Sump pumps
5. The supply to a UPS
6. The DC circuit of the UPS
7. Directly connected equipment downstream of the UPS
E2.16.2 Directly connected installations requiring RCD protection

The following installations must have RCD protection:

1. Catenary cables
2. Hot water systems
3. Low voltage outlets connected downstream on the UPS. The RCD can be installed at the outlet.
4. Lighting
E3 Electrical Switchroom

All switchrooms in this specification are referring to low voltage switchrooms unless specified otherwise. The specification for High Voltage switchroom is covered in SWC High Voltage Specification series.

There are two main types of switchrooms detailed in this specification, they are Permanent switchrooms and Prefabricated switchrooms. Prefabricated switchrooms will not be accepted without pre-design acceptance from Sydney Water’s technical and operational representatives.

For Network assets all new low voltage switchrooms shall be based on the current version of the Sydney Water DTC LV switchroom drawing set (DTC3000-DTC3006). If the DTC is fit for purpose it shall be used. Where modifications are required the DTCs and associated notes shall act as a guide. The designer must ensure the same design characteristics are maintained including but not limited to design life, wind load, fire resistance level, ventilation and cooling capacity.

The design of the Switchroom shall be verified and certified by an independent Chartered Professional Engineer (CPEng) of Engineers Australia and be in the National Engineering Register (NER) in structural discipline. Sydney Water reserves the right to request the designer and/or verifier to submit evidence of their certification. Sufficient verified drawings shall be provided for interfacing and any council submission requirements for the structure.

Standalone permanent switchrooms shall be considered as Class 8 buildings with type ‘C’ construction designed in accordance with the NCC and all relevant Australian Standards.

E3.1 General Requirement

Separate high voltage and low voltage switchrooms shall be provided. Consideration shall be made to allow for room for maintenance and future expansion. Please refer to Sydney Water High Voltage Specification series for detail requirements about High Voltage Switchroom.

Please refer to SDIMS0026 - Customer Delivery Facility Safety Signage Specification for all safety signage to be used for switchroom.

Please refer to E4.3 – Lighting and E4.4 General Power section for all lighting and general power requirements associated with switchroom design.

All cable penetrations shall be fire stopped. Switchrooms shall be sealed and vermin-proof.

Switchroom floors shall be flat and stable, and it shall be able to support all possible static and dynamic loads.

New switchrooms shall use Sydney Water standard locks and keys. The lock number shall be the same as existing switchrooms or assets on site.

E3.1.1 Fire Resistance

All switchrooms shall have a fire resistance level (FRL) in accordance with NCC requirements. All openings, ducts, trenches, cable ways or the like made for the entry of electrical conduits and cables through external walls shall be properly sealed to maintain the fire rating and water tightness. Consideration must be given to the need for the switchroom building to maintain the operation of equipment for as long as possible. A higher FRL may be required depending on the criticality, or function, of the equipment.

If an external wall is within 3m of any fire source louvres must not be located within that wall and shall be located in other walls. If a door is located within a wall which needs to achieve an FRL the door shall be tested to the required rating.

Switchrooms located in bushfire prone areas must comply with the latest version of AS3959 with additional measures undertaken for critical sites. These shall be confirmed with SWC during the design stage.
Fire extinguishers suitable for electrical fires shall be fitted in switchrooms at all treatment plants based on a site-specific risk assessment. The risk assessment shall be carried out in consultation with Sydney Water operation staff. If any works carried out at a site where there are no fire extinguishers, fire extinguishers must be made available for the site during the work.

E3.1.2 Doors
Each switchroom shall have a minimum of two exit doors, the follow door types shall be applied in this specification:

- Double door 2000 mm wide x 2500 mm high clear opening or greater to allow transport of equipment through.
- Single door 750 mm wide x 2000 mm high clear opening or greater for personnel access.

For permanent switchroom, the doors shall be heavy duty external grade solid timber. Ledged and braced with galvanised metal covering the exterior face. Heavy duty hinges shall be fitted.

For prefabricated switchroom, the doors shall be powder coated metal clad (Ultra external) solid core hung on a minimum of three S/S heavy duty butt hinges, seated in powder coated steel frames complete with locks.

Doors shall be designed and fire rated in accordance with National Construction Code (NCC) requirements. Doors shall be open to the outside and lockable from the outside only. The doors shall be openable from the inside by turning the door handle independently of whether the door has been locked from the outside. Doors shall be fitted with panic bar exit mechanisms to aid in emergency exit. Doors shall be fitted with seals and weather strips all around the frame, top and bottom to fully exclude water and dust entry.

E3.1.3 Air Conditioning unit
Heat load calculations shall be provided with consideration of all possible impacts and variables, such as: equipment loads, ambient load, heat generation device, general lights and power, etc.

The switchroom shall be installed with split system air-conditioning unit(s):

- If, based on the heat load calculations, the switchroom temperature will not be maintained below 40OC, or
- If specified.

Switchroom air-conditioning shall be appropriately sized to:

- Remove heat dissipated by electrical equipment, with cooling capacity to cater for current equipment heat load plus 30% capacity for future
- Prevent the formation of condensation
- Maintain the ambient temperature of electrical equipment below 35 degree C
- Maintain humidity within acceptable limits
- Fully seal the room to exclude external contaminants
- For SPSs and STPs the external air conditioning unit shall be heavy-duty corrosion-proof unit suitable for sewage gas environments.

The air conditioning units shall not be placed over switchgear. The installation of air conditioning units shall have suitable access for periodic maintenance activities. Openings in the roof are not permissible.

The air conditioner and ventilation units shall not ventilate directly onto the LV switchgear or equipment.

For prefabricated switchrooms, if the switchroom is on pedestal foundations, the external unit can be installed underneath the building provided there is sufficient space to meet other requirements. Prior acceptance is required from Sydney Water.
E3.1.4 Switchroom layout

Spare floor space (25% of room area) shall be allowed for future Switchroom installations.

Switchroom layout shall be such that:

- Any cubicle or equipment can be removed and re-installed without having to remove or disturb any other equipment or wiring in the room.
- There shall be no need to remove the roof of the switchroom to remove any equipment.
- Any cubicle or equipment to be mounted inside with a minimum of 600mm clearance passageway for evacuation even when removable parts are racked out to serviceable position or door opened.
- The location of electrical cubicles shall be arranged so that hot air from any other equipment/machinery is not directed onto the cubicles. Where possible, electrical cubicles shall not be mounted on, or against the western wall of superstructures.
- Comply with AS/NZS3000 requirements for clearance distance with adjacent equipment and building structures.

E3.1.5 Emergency Lighting and Smoke Detector

Trickle charged emergency lighting shall be provided indicating the exit and lighting the room sufficiently for personnel to safely exit during a full night-time power blackout. Each room shall have at least two emergency exit lights. Emergency lighting system testing facility shall be provided in each switchroom. All design and work shall be carried out in accordance with AS 2293.

Security lighting shall be provided to automatically switch on at night to illuminate the outside of the switchroom for security purposes. Security lighting installed outside shall be vandal-proof.

Smoke detection shall be provided at roof/ceiling level of the room and connected to the site Fire Detection and Alarm System. Vent fans and air-conditioners shall be interlocked such that they are switched off when a fire is detected in the switchroom.

E3.2 Permanent Switchroom

All walls shall be brick or tilt slab concrete. Vermin-proofed air bricks shall be provided in brick walls.

Roof shall be two layers, the top layer colour-bond metal roofing panel, the bottom layer structural concrete slab or pre-cast slabs. Openings in roof for skylights, vent fans or air-conditioning are not permissible.

Switchroom walls, roofs, ceilings and infinite access floors shall be of non-combustible construction.

Switchrooms shall be at ground level with paved vehicular access (roadway) up to the equipment access door and paved pedestrian access up to the person access door. Switchrooms shall be above the 1 in 100-year flood level. The floor of the switchroom shall be above the ground level around the switchroom by 150mm minimum and all conduits leading into the switchroom shall be sealed to avoid water ingress to the switchroom.

Unless accepted otherwise, permanent low voltage electrical switchrooms shall have infinite access floors of minimum 600mm and maximum 1000mm high for cables and cable trays. Areas under infinite access floor shall be adequately drained and sealed to keep the floor dry. The infinite access floor shall comply with the requirement in clause E3.4.

Switchboards installed in switchrooms with infinite access floor shall have independent hot dip galvanised stands which capable to support the entire weight of the switchboard plus 30% capacity for future. It is not acceptable to install switchboards on the infinite access floor.

The height of the switchroom from infinite access floor level to ceiling shall be a minimum of 3 metres and capable of housing all SCAs and MCCs when resting on 75mm plinths, provided SCAs and MCCs do not have plinths as part of the switchgear assembly. The ceiling height shall also consider the arc venting requirement from switchgear manufacture.
E3.3 Prefabricated Switchroom

The low voltage prefabricated switchroom with respect to the National Construction Code (NCC) in this document shall be regarded as Class 8 structures and are generally not considered to be habitable spaces.

E3.3.1 Design Loads

Wind load: The Switchroom shall be designed for N3 Wind classification to AS 4055.
Switchroom floor live load: A minimum uniformly distributed load of 7.5 kPa and a single point load of 5 kN.
Switchroom floor deflection: Maximum of 3 mm or span/500 whichever is more stringent.

E3.3.2 Switchroom Floor Framing and support

The prefabricated switchroom shall have robust welded (category SP) or bolted (8.8 grade) steel framing, unless otherwise stated. The floor-frame shall consist of perimeter beams and joists. Floor joists shall be typically at 1.8 - 2.5 m centres.

The floor framing shall be supported off the ground along the perimeter beams with steel columns, typically at centres of not less 2.0m. The floor frame design shall allow for lifting with all the equipment installed in the switch room within the nominated deflection tolerances. Lifting brackets shall be on the base-frame and shall be located as far as practicably possible in positions to provide for the most balanced lift.

The clearance below the Switchroom frame must ensure the Switchroom is above 1 in 100-year flood level. Also, given the clearance below the Switchroom frame, consideration should be given for equipment access during maintenance work.

All steelwork shall be in accordance with Clause 5 of SW Technical Specification Part 1 Civil Works.

The support columns shall be founded on reinforced concrete pads. The pad footings shall be proportioned so that the maximum differential settlement between the pad footings is 5 mm or spacing between the adjacent footings / 500 whichever is more stringent. The minimum size of the pad footings shall be not less than 800 mm x 800 mm x 250 mm thick. The top of the pad footing shall be located nominally 100 mm above the finished ground surface.

The minimum concrete grade for the pad footings shall be N25 to Clause 3 of Sydney Water Technical Specification Part 1 Civil Works.

All steelwork except colourbond sheeting shall be hot dip galvanised (HDG) to WSA 201 and SWC supplement.

E3.3.3 Steps, Landing and Access

Stairs and Landings shall be designed in accordance with the requirements of AS 1657.

Landings shall be fabricated using Web forge (or similar) grate.

Handrails shall be fabricated from Monowills type product (or equivalent) and shall be removable if placed adjacent to equipment access routes.

All landings not integrated into the floor frame shall be provided in kit form for assembly on site.

All stairs treads shall be manufactured using Web forge type product with serrated top surfaces. Handrails shall be fabricated from Monowills type product (or equivalent).

All stringers, stairs and landings shall be hot dip galvanised (HDG) in accordance with WSA201 and SWC Supplement.

All stairs shall be provided in kit form for assembly on site.

E3.3.4 Floor Coverings and Penetrations

The floor shall be:
• Made of precast panels secured to the supporting structural members with a minimum of M8 HDG bolts at a maximum spacing of 1m centres. The bolts shall be located in a recess and the recess shall be filled with cement grout on completion of installation.

• Has a fire rating that meets all the relevant requirements applicable to the application.

Floor penetrations shall be designed such that maximum access is provided to equipment gland plates. Structural members shall cross the Switchroom floor at centres to meet engineering requirements. These members shall be set at a depth below the floor equivalent to the height of the floor joists + the flooring material. These members shall be located between panel joints and shall not encroach into the cable zones. Floor joists shall not encroach into any cable penetrations. All floor penetrations shall be placed between the floor joists.

E3.3.5 Walls, Roof and Ceiling

The prefabricated switchroom shall have a minimum internal height of 3000mm with consideration for arc venting from the switchgear if required.

The prefabricated switchroom shall have a minimum internal height of 3000mm with consideration for arc venting from the switchgear if required.

The exterior linings of the wall shall be finished with pre-painted steel. This product shall provide a high durability paint finish and shall comply with AS 2728.

The walls and roof shall be framed using hot dip galvanised (HDG) structural steel framing system suited for use in modular structures.

The external wall profile shall be vertical running corrugated profile in standard/Ultra Colourbond steel range with the colour Pale Eucalypt.

Fiberglass Wall insulation shall be used to achieve an R1.8/2.0 insulation rating. The walls shall be fitted with sarking before cladding.

The interior of the walls shall be lined with fire rated plaster boards.

The external roof profile shall be Colourbond - Trimdeck Zincalume or similar.

Ceiling insulation shall be R2.0 foil faced fibreglass blanket. No gutters or down-pipes shall be provided.

The internal ceiling lining shall be with fire rated plaster boards.

All external flashings shall be fabricated from matching Colourbond flashing.

The roof shall use graduated purlins to provide a side slope roof.

E3.4 Infinite Access Floor

E3.4.1 General

The infinite access floor system shall consist of 600mm square modular panels positioned and supported on all sides by a rigid grid system of pedestal supported stringers securely fastened to a die formed steel pedestal head by a threaded fastener.

All panels should be removable by one person with a suction-type lifting device. All panels should be interchangeable except where cut for particular positions of the floor.

Where panels are cut to suit particular positions on the floor the cut edge shall be suitably treated to prevent corrosion or deformation due to the ingress of moisture or corrosive gases. The cut edges shall be sealed with a manufacturer approved sealant.

The complete flooring system shall be suitably treated to prevent corrosion or deformation from a humid salt laden atmosphere and corrosive sewage gases.
All components shall have positive contact for safe continuous electrical continuity of the entire floor under structure. Spring clips and other mechanical devices will not be permitted. A minimum of two (2) equipotential bonding points must be provided for the floor to connect to the local earth.

The complete flooring system shall be sturdy, rigid, firm and free of vibrations, rocking rattles, squeaks and other noises.

E3.4.2 Floor Panels

The 600mm x 600mm floor panels shall be capable of accepting a uniformly distributed load of 1000kg/sqm with a 1.6mm maximum deflection or a concentrated point load of 460kg applied with a 52mm diameter disc to give a deflection of no more than 1.8mm. The ultimate strength of the panel shall provide for a minimum safety factor of two (2).

The floor panel bottom shall be capable of additional pedestal support at any location without the use of other auxiliary components.

Floor panel materials shall be of a type that do not absorb moisture and which do not swell or distort when wet.

The floor panels shall have straight parallel edges to eliminate any visible gap between adjacent panels and the switchboard frames.

E3.4.3 Floor Panel Surface Material.

The floor panels shall be surfaced with a high-pressure laminate of 1.6mm thickness conforming to Australian Standard AS2924 "High-Pressure Decorative Laminate - Sheets made from thermosetting resins" and trimmed with extruded soft vinyl. The surface shall meet anti-static requirements.

The colour of the surface is to be beige or a suitable neutral toned colour. Samples are to be submitted to Sydney Water for acceptance.

E3.4.4 Under structure

The under-structure for this flooring system shall consist of pedestals supporting a rigid grid system.

The pedestal assembly shall be capable of supporting a 2000kg vertical load without permanent deformation of any part.

Each pedestal shall provide a minimum +/- 32mm height adjustment. Pedestal heads to consist of a die formed steel cap welded to a threaded stud with a levelling nut for vertical adjustment. A vibration proof positive locking mechanism shall be provided on each pedestal.

Pedestal base should consist of a steel tube with a minimum wall thickness of 2.5mm continuously fillet welded to a steel base plate 100mm square with a thickness of 3mm.

The main vertical body of each pedestal shall be in one continuous piece. Joints (including welded joints) will not be permitted.

Pedestal assemblies will be supplied in an electro-zinc plated and chromate treated finish.

The stringers shall be formed of hot dip galvanised steel and be capable, without panels in place, of supporting a concentrated load of 120kg at centre of a 600mm span without exceeding 172Mpa stress.

The stringers shall be securely fastened to the pedestal heads with a minimum 6mm diameter threaded fastener to provide a shear connection. The screw is to mate with a threaded hole in the pedestal head.

All stringers shall be easily removable without the use of special tools or devices. Fasteners are to be accessible from the top surface of the stringer.

Stringers shall have a semi-conductive polyethylene plenum seal located on top of the member.
A manufacture recommended perimeter support system shall be provided immediately adjacent to all walls including where part panels are installed. Either by use of pedestals and stringers or by fittings such as galvanised angle fixed to the wall. Details of the perimeter support system shall be submitted to Sydney Water for acceptance before any installation work will be permitted.

**E3.4.5 Installation**

The finished floor height shall be as stated on the relevant switch-room civil/structural drawings.

The maximum level variations for the floor shall be +/-1.6mm within 3 metres and +/-3.2mm over the whole installation.

The under-structure shall be connected to the site electrical earth and the total metal under-structure resistance shall not exceed 0.5 ohm as per AS 3017 requirements. The connection must be performed by a qualified electrician.

The pedestal base assembly shall be suitably secured and levelled with non-shrinking grout to the sub-floor. The pedestal assemblies shall be suitably tied and braced to maintain a rigid structure.

The Manufacturer or his authorised representative shall install the flooring system according to the Manufacturers specification.

The infinite access floor shall be installed only after the switchboard frames are installed. The floor panels shall be installed around the frames in straight parallel edges to eliminate any visible gap between the panels and the switchboard frames and well supported to avoid them tipping.

Where large sections of the floor panel (including unavoidable removal of the floor panel edge) have to be removed for access purposes, extra pedestal supports shall be installed.

The pedestals or their base assemblies shall not obstruct the conduits and/or access for cabling provided in the floor and walls of the substructure.
E4 Electrical Services

E4.1 Pits and Conduits

E4.1.1 General Requirement

Separate pit and conduit systems shall be provided for the high voltage and low voltage installations. Instrument and low voltage power cables may be laid in the same pit but in separate conduits. Barriers shall be provided in the pits to separate instrument and power cables.

All cable pits shall be spaced no more than 50 metres apart and provided at each turn of change in direction of conduit run.

The pits shall have a minimum of 1200 x 1200 clear opening and a 100 mm drain with vermin proof drain pipe to the nearest drainage system with non-return valves provided in the pits. Pits around gas hazardous areas shall have conduits designed for sealing against gas leaks.

All pit covers must comply with the requirements outlined in the Sewerage Code of Australia WSA 02 - 2002.2.2 Sydney Water Edition for MH (Manhole) Covers.

The last pit in the pit and conduit system shall be lower than the switchroom sub floor and be drained away to avoid water entry to the switchroom. The sub floor of a switchroom shall be graded to allow water flow to one end where there shall be a sump installed. This sump will allow excessive water in the sub floor to be contained and drained way using a portable sump pump as required.

Pits deeper than 1 metre shall have approved non-corrosive step iron installation for safe access.

For new low voltage installations, each conduit run shall have 50% additional conduits of each size installed for future use. Each pit shall be sized to for the listed conduits, and an additional 10% capacity.

For the final conduit run to an instrument (e.g. pressure, flow, level devices) no additional conduits are required.

For new high voltage installations, there shall be at least one 150mm spare conduit for future use.

Polypropylene draw wires shall be installed in all the spare conduits.

Conduits and fittings shall be PVC and comply with the Australian Standards. Conduits smaller than 50mm diameter shall not be used.

Conduits shall be in long lengths, straight, smooth and free from rags, burrs and sharp edges. Off-cuts shall not be used to fabricate long lengths of conduit. Conduits shall be set wherever possible to minimise the number of joints.

Conduits entering pits shall be bell mouth to eliminate damage to cables during cable pull. All gaps around the conduit entry to pit shall be sealed.

External conduits and above ground conduits subject to the possibility of damage shall be mechanically protected.

A 150mm wide yellow or orange conductive marker tape shall be laid above all underground electrical conduits.

For high voltage cable installations, cable route markers shall be installed every 25 metres on straight runs, at each change of direction and at each side of a road crossing. Cable markers shall be brass engraved labels on hard surface and flexible "Telstra type" post for open areas.

Bends shall be at least 12 times the cable diameter and shall be formed with proper formers. Correctly sized springs shall be used to form bends in UPVC conduits. Conduits manipulated or bent must maintain true effective diameter and shape at all parts of the bend.

Saddles shall be stainless steel double-sided for steel and PVC conduits. PVC saddles shall not be used.
Saddles supporting conduits shall be effectively secured to the surface on which they run with plastic plugs up to No 8 gauge stainless steel screws, for larger fastenings stainless steel Dyna bolts or Loxin anchors or chemical anchors shall be used. Saddles shall be proprietary brand installed as supplied.

**E4.1.2 Heavy Duty UPVC Conduits**

This conduit is for both underground use and above ground use. When used above ground the conduit shall be painted to prevent deterioration of the conduit due to exposure to sunlight. All fittings shall be of the same material as the conduit and all joints shall be made with an adhesive cement recommended by the supplier of contrasting colour.

**E4.1.3 Rigid Metallic Conduits and Fittings**

All steel conduits shall be galvanised (‘heavy protection’) with screwed joints and screwed terminations. End joints and terminations shall be made by either screwing the conduit into the fitting or by securing the conduit to the fitting or accessory with circular galvanised lock nuts screwed onto the conduit. In the latter case the entry hole must be close fitting to the conduit.

Steel conduits shall have screwed ends and screwed joints, all threads being painted with aluminium paint. Steel conduits shall be electrically and mechanically continuous.

Electrical continuity tests shall be carried out prior to the installation of draw cords.

Joints shall be protected against corrosion and effectively sealed against entry of water or moisture and all associated fittings shall be either galvanised steel or galvanised malleable cast iron. Bends shall be of large radius. The pipe run shall be electrically continuous and the enclosure shall be earthed at both ends.

Where steel conduits are exposed to the weather, installed in service trenches, or in locations subject to dampness or condensation, the conduits and associated fittings shall have protective coating meeting the requirements of "medium protection" or "heavy protection".

Wherever steel enclosures for cables are buried in the ground or run in concrete trenches, the enclosures shall be galvanised medium quality pipe to AS 1074 [generally known as galvanised water pipe]. Joints shall be protected against corrosion and effectively sealed against entry of water or moisture and all associated fittings shall be either galvanised steel or galvanised malleable cast iron. Bends shall be of large radius. The pipe run shall be electrically continuous and the enclosure shall be earthed at both ends.

**E4.1.4 Light Duty PVC Conduits and Fittings**

This conduit shall be used in above ground positions not exposed to mechanical damage.

All associated plastic fittings except saddles shall be of the same material as for the conduits.

All conduits, plastic fittings and adhesive cement shall be procured from the same manufacturer and the manufacturer’s recommended procedures shall be adopted for the making of joints. All joints shall be made with an adhesive cement recommended by the supplier.

All standard size wall boxes shall be of the same material as the conduit. Where special size boxes are indicated and where such boxes are not obtainable in PVC, use pre-fabricated metal boxes which shall be effectively earthed. UPVC conduit shall be fixed to a PVC wall box with a screwed PVC adaptor and lock nuts, unless the conduit enters the wall box via a moulded conduit entry.

**E4.1.5 Conduits in Concrete**

Unless otherwise indicated, conduits shall not be run in the concrete toppings. Conduits run in the fill under floor slabs shall be HD-UPVC. Corrugated conduits are not permitted.

Conduits shall be securely fixed to the reinforcing rods, passing above a single layer of rods or between a double layer of rods, generally mid-way in the thickness of the slab. Attention shall be paid to routes of conduits in slabs to avoid crossover and to keep the number of conduits in any one location to a minimum. Conduits in slabs shall be spaced not less than 75 mm apart.
Conduits may cross, provided they intersect at angles greater than 30 degrees and are tied together. The minimum cover over the conduits shall not be less than the conduit diameter or 20 mm, whichever is larger.

Conduits shall not be installed in a slab through the areas around a column to one quarter the distance from the column to the next column, supporting beam or wall, except to outlets in the area.

Unless otherwise indicated, the maximum diameter of conduits in suspended slabs shall be 25mm, spaced not less than 75 mm apart.

Unless otherwise indicated, a maximum of four (4) 20 mm diameter conduits are permitted in each column. No more than two (2) conduits shall cross any one face of the column and all conduits inserted) shall be placed centrally.

Bends in conduits entering the columns shall have a minimum radius of 300 mm. Structural columns shall not be chased for conduit installation.

Conduits in concrete shall be inspected by a nominated Sydney Water representative prior to pouring concrete. Sufficient notice, time to alterations or modifications found necessary during inspection shall be allowed. Attendance by a nominated Sydney Water representative is mandatory during the concrete pouring to ensure that conduits are not displaced, broken or damaged.

**E4.1.6 Installation**

UPVC conduit shall not be installed on exterior surfaces. However, short runs of HD-UPVC pipes from underground sub mains may be surface run where they enter an existing building if it is not practicable to conceal them, provided that they are suitably protected from mechanical damage and sunlight.

Jointing of conduits and fittings shall be carried out strictly in accordance with the manufacturer's recommendations. Expansion joints shall be installed in all conduit runs to manufacturer's recommendations.

All circuits, originating from any distribution board, shall be run in a separate conduit.

Conduits which are installed underground or concealed in concrete floor slabs, foundations or the like shall be cleared of foreign material and obstructions after installation and prior to cables or draw wires being drawn in.

Conduits shall be installed so that the system may be wired using the "Draw in Loop in" system.

The installation of elbows, tees, etc. is prohibited on conduits installed in inaccessible locations.

All conduits shall be effectively capped during construction.

Conduits shall be securely fixed to building members and shall be adequately supported during all stages of building construction. [Particular care shall be taken to support PVC conduit upstand.] Generally all conduits shall be concealed.

Surface conduits shall be made to harmonise as far as practicable with the architectural features of the building. Surface conduits shall be run in vertical and horizontal directions except where it is desirable to follow the line of the building.

Directly buried conduits shall be bedded on 50 mm minimum of clean sand and covered by a further 50 mm of clean sand before backfilling the trench. The conduits shall be covered with stone free spoil removed from the trench. After laying the conduits in unpaved areas, the trench shall be backfilled and consolidated to about 10 mm above the natural ground level. All excess spoil shall be removed from the site.

Saddles supporting conduits shall be effectively secured to the surface on which they are run. Saddles shall be sized for the conduit being supported.

Horizontal conduit runs which are exposed to weather or where moisture would be retained between the conduit and the wall shall be installed using saddle spacers clear of the surface.
Conduits shall terminate in the luminaries, equipment and accessories or in wall boxes and junction boxes of a type compatible with the installation. Plain to screwed adaptors shall be used to terminate conduits into fittings.

Materials used to lubricate cables whilst drawing-in to conduits shall be non-conductive, non-abrasive and non-hygroscopic.

All conduits and pipes 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.

Pipes terminated outside a building shall be taken beyond the line of paving, a draw cord shall be secured and the pipe capped, waterproofed and location marked. All conduits terminating inside switchboards and pits and walls shall be bell mouthed.

Inspection fittings and the like shall be accessible.

UPVC conduits installed in accessible roof spaces and the like, which may be walked on, shall be protected by timber battens.

Draw-in boxes shall be provided at suitable intervals not exceeding 30 m in straight runs, and at intervals not exceeding 25 m in other runs including points of directional changes.

Expansion joints shall be provided in the concrete slab and outdoor installations.

**E4.2 Reticulation and Wiring**

**E4.2.1 Setting Out of Runs**

In setting out the work, the following directions shall be followed:

- Cables and conduits shall be fixed parallel to building members, walls, doors, etc. and shall be run on the square wherever possible. In slabs, conduits may be run diagonally as directed.
- All conduits shall be concealed in wall chases, built into brick work, run in wall cavities, false ceilings and infinite access floors or in floor slabs.
- Conduit runs in roof spaces shall be located below the roof heat insulation and sarking.
- Recessed wiring in cables to switches, outlets and similar terminations shall be protected by conduit drops sized to accept the cables and shall originate at an accessible point in the roof space.
- All cables and conduits shall be arranged in a neat and workmanlike appearance.
- Cabling shall be installed so that it may be fully replaced. Where cabling passes through an inaccessible space it shall be capable of being drawn through the space. Note: This may require the installation of conduit through the space.
- Underground pipes containing cables shall be laid straight with minimum deviation from the horizontal and vertical planes.
- Cable runs in infinite access floors shall be in cable trays.

**E4.2.2 Underground reticulation**

To preclude damage, cables shall be drawn using rollers, drum jacks and a cable stocking of the correct size.

Where required by the Wiring Rules, mechanical protection for cables, other than those enclosed in heavy duty enclosures to AS 2053 or galvanised medium quality pipe to AS 1074, shall be proprietary manufactured or precast bricks or covers, with the letters "ELECTRIC" permanently indented. Covers cast on site will not be accepted.

Where electric bricks or covers are not required over underground wiring, a 150 mm wide yellow or orange conductive marker tape bearing the words "WARNING - ELECTRIC CABLE BURIED BELOW" or similar shall be laid in the trench 150 mm below ground level for the entire length.
**E4.2.3 Penetrations**

Generally, all penetrations and repairs to penetrations shall be coordinated as indicated. Penetrations through damp courses will not be permitted.

Penetrations through Waterproof Membranes:
Conduits which enter a building at ground level shall run under the waterproof membrane and vertically penetrate the membrane and the concrete slab at the appropriate position.

Where conduits pass through roofs, adequate sealing shall be provided between the conduit and the waterproof membrane.

Penetrations through External or Existing Structure:
Where conduits pass through external walls, existing ground floor slabs or existing ground floor beams, a penetration 10mm greater than the conduit diameter shall be provided. The penetration space around the conduit shall be made waterproof by using a proprietary sealing method.

**E4.3 Lighting**

**E4.3.1 General**

Adequate lighting shall be provided in all areas of the new/upgraded plant including all rooms, corridors and galleries and evenly distributed for both perimeter lighting and throughout the external plant for daytime and night-time operation and maintenance to be carried out on equipment. All lighting design shall comply with the requirements in AS 1680, AS 2293 and National Construction Code.

A detail lighting study shall be carried out to determine the minimum illuminance needs to be maintained for each area in accordance to the requirements in AS 1680 and National Construction Code.

Lighting must be provided to illuminate wet wells, inlet maintenance holes, valve chambers and any above ground emergency bypass arrangements to permit the performance of maintenance under low light conditions.

The cabling and all associated components must maintain the same IP rating as the light fitting for the entire cable run. Where junction boxes are installed, the junction box must be installed above the overflow level.

For indoor lighting, lighting switches, two way or multi-way where appropriate, shall be provided at all exit doors. Outdoor lighting must be vandal proof.

Light switches for switchrooms must be installed inside the switchroom adjacent to the exit doors.

All luminaries shall be industrial type and the following lighting type shall be used:

- High power LED (Preferred) or high power factor fluorescent
- High bay mercury
- IP55 fittings for hose-proof and dust-proof application

Security lighting must automatically switch on at nightfall and switch off at sunrise. It must be adjustable for light sensitivity.

All lighting shall be designed in accordance with the requirements of the Australian Standards.

Each lighting circuit shall be protected by an RCD. Minimum size of the circuit breakers feeding lights shall be 20A. No more than 20 lighting points shall be fed from a circuit breaker. Final sub-circuit in a distribution board shall be of single purpose only.

All luminaries except external pole-mounted or high mast lighting shall be installed in locations, which could be accessed with portable platform ladders not longer than 5 metres. It shall be possible to replace the
fittings without the use of access equipment (scaffoldings and / or machineries like cranes, cherry pickers etc.). Pole mounted luminaires must be mounted on tilt down swivel poles that are operated by one (1) person.

All fluorescent light fittings installed in machinery rooms, galleries and any other locations open to external environment shall be IP65 rated and non-corrosive with poly-carbon diffuser.

Light fittings near the sea or in corrosive atmosphere shall be of marine grade aluminium.

Light switches shall be a minimum 10 A rating, complying with AS 3133 and the following:

1. Light switches shall be of the flush type, fixed in wall boxes to suit the installation, and located at room and gallery entrances. Two-way switches shall be supplied and installed for corridors and galleries.

2. Switch plates for switches shall be impact resistant plastic mouldings, suitably reinforced, of selected colour and finish.

3. Ironclad switches shall have the toggle fully recessed or protected by shrouds.

4. Switches exposed to weather, or in locations subject to dampness or condensation shall be impact resistant, fully insulated, moulded plastic or cast metal, and shall have a rotary action positive contact switch. The enclosure shall be minimum IP56 and effectively sealed against the ingress of water or moisture.

5. Switch mechanisms, fitted to a flush plate, shall be secured to the plate with retaining screws, or constructed so that switch mechanisms cannot be displaced.

Light switches shall be supplied and installed adjacent to door openings and shall be installed on the lock side of the door at each entry to each room. Flush mounted wall switches shall be located vertically with a maximum of four switches to a gang plate.

Switches shall not be installed across the junction of different wall finishes.

Adjacent switches connected to different phases shall be shrouded.

Mounting heights for switches shall be approximately 1200 mm to the centre of plate above floor level, unless otherwise indicated.

**E4.3.2 Emergency Lighting**

Emergency luminaires shall be supplied and installed in all rooms, corridors and galleries to provide sufficient lighting for evacuation of personnel in case of power blackout at night. Emergency exit signs with minimum 100mm high lettering shall be fitted above exit doors. Emergency exit signs shall be located such that at any location within the site there is uninterrupted view to at least one of them. The luminaires shall be of the self-maintained, self-contained type with battery backup supply, in accordance with AS 2293.1. They shall be tested using proprietary brand test station as per AS 2293.3. Size of backup battery shall be sufficient for operation of 90 minutes in service and 120 minutes during initial commissioning.

**E4.3.3 External Lighting**

External areas shall be designed to the following:

- Minimum horizontal illuminance around plant and storage areas shall be 3 lux. Where horizontal illuminance falls below this value in less important perimeter areas, the horizontal illuminance shall be at least 1 lux and vertical illuminance at least 3 lux.

- Minimum horizontal illuminance on access road shall be 1.5 lux with an average of 5 lux.

- Floodlights shall be cut-off type and not projector type to minimise glare or unwanted spill light into neighbourhood

- Exterior Vandal resistant light fittings shall be provided over external doors

Street lighting shall be installed every 30 metres on incoming access roads.
E4.3.4 Security Lighting

Security lights (building and street) shall be automatically controlled by a light sensitive switch or photo electric cell (PE Cell). The PE Cell shall be mounted on the exterior wall of the building facing a Southerly direction. A "Manual-Off-Auto" (MOA) selector switch shall be supplied and installed at building exits for each new building. The MOA switch shall be located such that it is inaccessible after the building is locked up. When selected "Auto" the lights shall operate by the switching of the PE Cell. When selected "Manual" the PE Cell shall be overridden and the security lights shall be switched on. When selected "Off" no operation of the security lights shall be possible. The security lights shall be minimum:

- Pole height - 4.5 m
- Light Fittings – Metal halide 450 watts rated fitted with 150 watts lamp.
- Enclosure IP65

E4.4 General Power

General power socket-outlets (GPOs) shall be provided for buildings and general maintenance. All outlets and switches shall be industrial type.

In indoor areas such as rooms, corridors and galleries with plant or equipment, there shall be:

- Weatherproof (IP54) 230V socket-outlets (minimum 10 amp rating). Minimum one per wall and spaced one every 15m for walls longer than 15m
- Two weatherproof (IP54) 5 pin 3 phase socket-outlet. One rated for 20 amp and one rated at 30 amp.

For outdoor areas, there shall be one 230V single phase 10A and one 400V three phase 30A weatherproof (IP56) socket-outlets every 25 m for each tank or process unit.

Each 3 phase socket outlet shall be supplied by an individual circuit breaker. Each socket circuit shall be individually protected by a residual current device (RCD).

Minimum size of the circuit breakers feeding GPOs shall be 20A. Final sub-circuit in a distribution board shall be of single purpose only.

Socket-outlets for hazardous areas shall be of the appropriate classification.

GPOs shall be of the combination switch socket type, fitted with safety shutters, and shall be selected to meet the requirements of the location and function. Socket outlets shall have the earth pin located at the 6 o’clock position and shall be polarised as recommended in the Wiring Rules. Unless otherwise indicated, outlets shall have a 10A rating.

Unless otherwise indicated, flush plates for outlets other than ironclad, shall be impact resistant plastic mouldings, suitably reinforced, of selected colour and finish.

Generally, power outlets shall be located at a height of 460 mm above finished floor level and 250 mm above bench tops. In change rooms, toilets, wash rooms and stores, power outlets shall be at a height of 1100 mm above finished floor level. In damp areas the requirements of the Wiring Rules are satisfied at all times.

E4.5 Fire Detection and Security Equipment

Fire detection system and alarms shall be provided in all buildings, rooms and galleries in accordance with AS 1670.

On Treatment plants, fire systems must interface to the relevant site systems (e.g. security, SCADA, etc). Where required, the fire systems must be interlocked to ventilation systems and operate as required. Any new installations must integrate into the existing fire system and be of the same manufacturer and model where possible.

For Network sites, where required, the fire system shall provide detection and local alarm only.
A security system shall be provided to monitor and alarm in case of security breaches for administration building, switchrooms and other areas as specified.

**E4.6 Flammable Gas Detectors Systems**

Gas detection system(s) shall be provided for all gas hazardous area(s). The alarm signal shall be wired to the IIICATS and plant SCADA system. The control panel shall be installed outside the gas hazardous area. Upon detection of gas, the system shall shut down the electrical power supply including batteries and UPS's.

**E4.7 Earthing**

**E4.7.1 General**

The earthing system for the installation must be combined earthing system in accordance with the requirements in AS/NZS 3000 and AS2067. Subject to Supply Authority requirements, incoming supply cables must be earthed at both ends.

Based on the earthing reports generated in accordance with the System Study requirements in Section 17, earthing arrangements and other related details must be provided to SWC for review prior to installation proceeding. The detail of earthing report requirements has been documented in section E17.

The earthing system verification and testing shall be in accordance with AS 3000 and AS 3017. Relevant earthing test and verification shall be carried out before and after the installation. Notwithstanding some provisions of AS/NZS 3000 and AS/NZS 3017 regarding use of constructional bolts or studs for earthing or earthing terminals, 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.

**E4.7.2 Main earth and neutral bar**

The main earth and neutral bars shall be:

- Hot dip tinned copper
- Sized adequately and labelled in accordance with AS 3000
- Located such that it is easily accessible for maintenance and future work.
- Mounted on a solid structure to allow connections to be appropriately torqued
- All connections are to be clearly and permanently labelled with stainless steel fixtures with cable numbers which indicate their destinations.
- Having a minimum of total 30% spare pre punched holes complete with bolts, washers and nuts fitted, the spare connections shall be at the ends of the bar.
- Main earth and neutral connections must have a minimum of 50mm spacing from adjacent connections to permit tong meter testing when required.
- The main earth and neutral bars should be mounted at a height that earth cables can be adjusted sideways to allow sufficient space for easy access of a clamp meter.

**E4.7.3 Earth electrodes**

Earth electrodes shall be copper plated or copper clad steel, and shall be driven to a minimum depth of 5 metres. Where the ground permits, the electrodes could be of an extensible type to enable improvement in the earth resistance by extending electrodes and driving them deeper. Bare earth conductors shall not be used unless otherwise detailed.

The connection at the top of all earth electrodes shall be installed in appropriated sized pits and the pit covers shall comply with E4.1.1.
All earth electrodes shall be provided with an accessible removable type connection or link or other appropriate means to enable resistance tests to be carried out. The disconnection of individual earth electrode during testing shall not adversely affect to the integrity of the earthing system.

**E4.7.4 Equipotential Bonding**

All electrical equipment, exposed metal on which electrical equipment is mounted including metal cable glands, electrical cabinets, cable ladders, armouring and screening and all conductive structures within the zone of arm’s reach as defined in AS/NZS 3000 shall be bonded to earth. The equipotential bonding conductor must be a minimum of 4 mm² earth wire.

All conductive cable ladder sections shall be bonded to adjacent cable ladders at their joints via a 4 mm² earth wire or flat copper braid bond.

**E4.8 Lightning Protection**

Lightning protection system shall provide protection against lightning strikes covered in AS 1768 section 1.1.

A lightning system assessment report in accordance with AS 1768 shall be provided at in accordance with Section 17. If the result of the assessment indicates that lightning protection is required, the lightning protection shall be provided and comply with AS/NZS 1768. As a minimum, the design work shall provide detail lightning protection design including detail calculations, schematics and equipment schedule to SWC for acceptance.

Buildings, structures and plants shall be protected against lightning strikes by air termination and shall be bonded to earth by down conductors. Height of the lightning protection poles / towers shall be limited to 10 metres unless accepted otherwise.

Vertical air terminations shall consist of a single copper rod sized in accordance with AS/NZS 1768.

Tape conductors shall be copper and held in position by copper saddles or clips at a spacing of not more than 1000mm.

All bolts, nuts, washers and screws employed shall be stainless steel.

Removable test links shall be installed in every down conductor.

Down conductors shall be bonded to the earthing system by a short length of flexible copper conductor and permanent exothermic welds.

Earth rods shall be housed in inspection pits clearly labelled 'Lightning Protection Earth'.

The lightning protection system shall be bonded to all services as described in AS/NZS 1768.

Earthing rods and services bonding materials shall be selected in order to minimise corrosion. Resistivity and pH measurements of the soil shall be taken. Earth electrodes and services bonds shall be guaranteed against corrosion for a period of thirty years.

Testing shall be carried out to verify that the lightning protection system complies with AS 1768. Testing results and results of the soil resistivity, soil pH measurements, earth resistance test shall be provided to Sydney Water.
E5 High Voltage Equipment System and Installation

E5.1 General

This Clause lists the minimum technical requirements for the design, manufacture, supply and delivery of High Voltage (HV) and related equipment.

All equipment supplied and modifications carried out to the existing equipment shall comply with the appropriate latest issues of Australian Standard or, in their absence, the latest IEC Standards.

Except where the specification requires a higher standard, all work shall be carried out in accordance with the latest edition of AS/NZS 3000 (SAA Wiring Rules), AS/NZS 3008.1.1, the services rules of the electricity distributor, and all relevant statutory authorities. Electrical installations operating at high voltage and earthing shall be designed and installed in accordance with AS 2067.

All power system studies shall be carried out using the latest version of SKM Power tools for Windows Version.

When working in high voltage areas or installing/working on high voltage related equipment, all work shall comply with Sydney Water High Voltage Operating Procedures.

E5.2 Equipment Specification

High voltage and related equipment shall comply with the following specifications which are available at request.

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<tr>
<th>No.</th>
<th>Reference</th>
<th>Description</th>
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<td>HV Switchgear</td>
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</tr>
</tbody>
</table>
E6 Not Used
E7 Not Used
E8 Not Used
E9.1 General
This covers the 400V main switchboards, distribution switchboards, motor control centres (MCCs), stand-alone motor starters and outdoor electrical kiosk type distribution and motor starter units. These are generally known as switchgear and controlgear assembly (SCA). The motor starters can be direct-on-line, electronic soft starters or variable speed drive units.

The SCA that have a rated nominal current of greater than 800 A per phase shall have an arc flash assessment as per the requirements in Section E2 and E17. The switchboard design must include agreed mitigation methods to ensure the final incident energy is limited to the level accepted SWC. Upon acceptance of the final Arc Flash assessment results, labels shall be fitted to the SCA indicating related PPE level, appropriated working distance and arc flash boundary.

The 400V main supply distribution section shall be fitted with clear, flat and non-combustible rigid shield to prevent personnel from coming in contact with live terminals.

Switchboards with two incoming supplies shall be separated into two sections via a bus tie. All process drives shall be distributed between the two sections so that shutting down one section will not impact upon the normal operation of the related processes. Mechanical or key interlocks shall be provided (see clause E2.7).

If on-site generators are designed to connect to a switchboard, the following generator related signals shall be made available to SCADA:

- Current
- Voltage
- Power
- Running/stopped
- Auto/manual mode selection
- Generator protection operated
- Condition monitoring signals

E9.1.1 SCA Switching Operation
Local switching operation means directly operating switches / push buttons in front on the SCA panel.

Remote switching operation means operate switches / push buttons outside the area of which the SCA is located, using a designated remote switching panel.

On each SCA, Isolators and circuit breakers equal to or exceeding 800A per phase for power distribution, and isolation switches for drive size from 250kw (inclusive) and above, must be capable to be operated from a remote switching panel.

Remote switching operation must only be enabled or disabled via designated selector switches on the respective SCA panels. When the selector switch is in remote mode, it must be able to be operated from both local switching and remote switching. When the selector switch is in the local mode, it must able to be operated from local switching only.

Both local and remote switching operation must not defeat SCA mechanical or electrical interlock arrangement.

E9.2 Indoor SCA (including MCCs)
Indoors refers to inside a building. All other environments are to be treated as outdoors.
The SCA shall be constructed and tested in accordance with the requirements of AS/NZS 61439.1. Form 3B or Form 4 assembly shall be used if the nominal supply current to the switchboard is 800 A or more per phase. The SCA shall be constructed to withstand prospective fault level. Form 3B or Form 4 switchboard assembly maybe required at lower nominal current levels when specifically requested by SWC.

The entire SCA and assembly must have verified testing in accordance with AS/NZS61439.1 Section 10.

For any component of the SCA rated greater than or equal to 800A, that entire SCA must have internal arcing fault tests in accordance to AS/NZS61439.1 Appendix ZD including the special tests in ZD6.

When designing the SCA, the prospective fault current must assume the practical worst case of operation i.e. all energy sources connected and supplying power. The designer must consider any loads, power factor and harmonic devices that may contribute to the fault.

The SCA shall have been subjected to temperature rise testing as detailed in AS/NZS 61439.1. The maximum surface temperature of any part of the SCA shall not exceed the values set down in AS/NZS 61439.1 with an overriding maximum temperature of 60ºC.

The main panel, doors and covers shall be manufactured from 2mm (minimum) cold rolled zinc seal sheet steel. The doors shall be braced to prevent flexing. The panel door with equipment installed shall withstand any flexing or wobbling during opening or closing the door. All equipment mounting plates shall be 3mm minimum thickness. Door exceeding 500mm wide or 750mm high shall have internal channel stiffeners every 750mm.

Door latches shall be capable of being held open at 120 degrees fully open position. The latch shall be a mechanical heavy duty one. Gas struts are not acceptable.

Door seal shall be minimum 15mm wide, neoprene held in by continuous metal retainer as well as adhesive.

The degree of protection against the ingress of foreign bodies shall be a minimum of IP54 (IP52 if installed in air conditioned switchrooms).

All cubicles forming the assembly, irrespective of the equipment to be accommodated, shall be of uniform height and depth. The fronts of the cubicles shall, as far as practicable, be of similar construction so that the complete assembly presents a uniform appearance.

The SCA shall be designed and constructed to allow future expansion by addition of sections at either end.

E9.3 Outdoor SCA
SCA’s that are permitted to be installed in an outdoor environment shall either be designed and verified by testing to suit the outdoor environment, or an indoor SCA housed in an outdoor enclosure and the combination of both are designed and verified by testing to suit the outdoor environment. Outdoor SCA shall comply with all indoor SCA requirements in Section E9.2. In addition, Outdoor SCA shall comply with following elevated requirements.

The SCA must be installed on a 100mm plinth mounted on a hardstand, with the hardstand above the 1% AEP level.

Outdoor SCA’s shall be manufactured from 2mm (minimum) grade 316 stainless steel.

The degree of protection against the ingress of foreign bodies shall be a minimum of IP54 for outdoor SCA’s.

Outdoor SCA’s and all components shall be designed to suit maximum ambient temperature of +55 degree C, and maximum 24 hours average temperature of +35 degree C.
Variable speed drives rated up to 22kW can be installed in outdoor SCA subject to satisfactory heat dissipation calculation confirming temperature requirements.

Variable speed drives rated greater than 22kW shall not be installed in outdoor SCAs.

**E9.4 Motor Starter**

**E9.4.1 General**

Each motor starter shall have the following equipment as appropriate:

A combination of contactors, thermal overloads and relays and where required elsewhere in this specification, motor winding over-temperature relays, motor bearing over-temperature relays, pump bearing over-temperature relays, timers, phase failure relays, phase rotation relays, motion detectors, under speed sensor relays, electronic shear pins, VSDs and speed controllers, soft starters, current transformers, ammeters, current transducers, power transducers. In particular:

- a) Ammeters shall be either 1A or 5A moving iron with a Class 1.0 metering CT in starters rated more than 30A.
- b) The triple pole main contactor shall have minimum two normally open and two normally closed auxiliary contacts.
- c) Three phase thermal overload and relay system. The protection relay shall be auto-resetting. Latching shall be done in the PLC.
- d) PTC thermistor relay where required elsewhere in this specification.
- e) RTD (Pt100) relay where required elsewhere in this specification.
- f) Control relay for remote start/stop, 24V dc operating coil with minimum 4 changeover contacts.
- g) Control relay for remote reset, 24V dc operating coil with minimum 4 changeover contacts.
- h) Circuit Breaker for the control circuit. The circuit breaker shall have a normally open auxiliary contact wired out to the terminal strip.
- i) Terminal strip in the cable zone of the MCC.
- j) Three phase motor circuit breaker with interlocking facilities with the motor starter door latching handle. The circuit breaker shall have a normally open auxiliary contact wired out to the terminal strip.
- k) Variable Speed Drive unit or Soft Starter as required for the process and/or to reduce the starting current where considered necessary for larger motors.
- l) Terminals to accept all related components mounted external to the starter.
- m) Hard wired drive failed indication on starter doors.
- n) Electronic shear pin for equipment which requires overdrive protection such as conveyors.
- o) The motor starter shall incorporate under speed sensor relays or motion detectors for drives as required by the process.

If digital protection relays are proposed, they shall be based on models currently used by Sydney Water. And capable of communicating with plant SCADA system and in accordance with the Treatment Plant SCADA Standards and associated standard template drawings and schematic diagrams and subject to Sydney Water acceptance.

In addition, starters shall comply with the Treatment Plant SCADA Standards and associated standard template drawings and schematic diagrams. If smart starters are proposed, they shall be the type approved by Sydney Water and comply with Sydney Water’s standard template drawings for smart starters.
E9.4.2 Stand-alone motor starters

Stand-alone motor starters shall be Form 1 SCA floor mount or wall mount units with only front access. Cable connection shall be from bottom of unit.

The degree of protection against the ingress of foreign bodies shall be a minimum of IP54 for indoor units and IP56 for outdoor units.

Stand–alone motor starters shall be provided with Modbus/RS485 interface to communicate with IICATS.

E9.4.3 Isolators

Isolators shall be rated for the maximum capacity of the associated starter or contactor and shall be suitable for breaking locked rotor motor current. It shall be possible to operate all isolators without exposing any ‘live’ metal. Isolator operating handles shall preferably be mounted independently of doors and shall be interlocked to prevent the door being opened with the switch closed or the switch being closed with the door open. However, provision shall be made for authorised personnel to defeat the interlocks for test purposes. Interlocks shall comply with AS 61439.

All isolators shall display clearly ‘ON’ or ‘OFF’ for each switching position. These provisions are applicable to circuit breakers and fuse-switches where they function as isolators in addition to their protection functions.

When performing isolation for motor starters, power isolators for each motor starter shall be pad lockable in an OFF position using a standard padlock or a multi-locking device.

Isolators shall be mechanically rated to a minimum of 30,000 no-load operating cycles. A utilisation category shall be selected based on the application with a minimum of “AC-3” and “DC-3”.

E9.5 Construction

E9.5.1 General

All SCAs must have bus copper bar system installed to connect and distribute to all incoming and outgoing units. Cable reticulation will not be accepted.

All access to the SCA shall be from the front. SCA’s which require back access to reach horizontal or vertical busbars will not be accepted. Covers to the vertical busbar compartment shall be in two pieces with handles for easy removal. All exposed conductors need to be shrouded to IP2X when cabinet doors are opened or removed.

The main busbars shall be identified as red/white/blue top to bottom, left to right or front to back. All busbars shall be tinned. The busbars and joints shall be sealed or shrouded to the requirement of the electricity distributor. The busbar shall only carry the weight of the cable within its designed withstand mechanical load in accordance with AS 61439.8, cables shall be independently support if they exceed the busbar withstand mechanical load limit.

Main neutral and earth bars shall be provided within the SCA with the neutral connected to the terminal strip of each functional unit. The main earth shall be tinned copper with a minimum cross section of 25 x 6mm capable of carrying the prospective fault current. The earth bar shall be tapped 4mm at 20mm spacing where it passes through cable zones.

E9.5.2 Earthing

An earth shall be provided at each separate frame, functional units, cubicles of the kiosk/SCA/MCC and all gland plates, hinged doors (internal and external) and other metal components such as weather shields and equipment’s mounting plates shall be effectively bonded to the earth bar using a minimum of 4 mm² earth wire. After installation, an earth resistance test of the main earth conductor shall be carried out in compliance with AS/NZS3017 and the value shall be recorded in the relevant documentations. MEN links shall be provided.
E9.6 Internal Wiring

Each terminal strip shall be identified with the full cable number of the cable it is provided for, with the label being white black white engraved plastic and shall be affixed into the terminals with nylon screws or adjacent to the strip with M3 metal screws, nuts and washers.

Cable number shall consist of the following:

- A number, which shall be the number of the drive to which the cable is connected, e.g. 9162.
- A capital letter number such as C, I P to denote the type of cable.
- A cable sequence number which identifies the cable among the total number of cables connected to the particular drive, e.g. the third cable which is a power cable for drive 9162 would be 9162.P03.

This then shall be the main identification label for the terminal strip provided for this cable: 9162.P03. In addition, each separate terminal provided for each core of a cable shall be labelled with its respective core number or colour or other designation.

The colour of the insulation or covering of conductors used as fixed wiring shall be as follows:

<table>
<thead>
<tr>
<th>ITEM</th>
<th>WIRING AND/OR CONDUCTORS</th>
<th>COLOURS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase</td>
<td>Red Phase</td>
<td>Red (R)</td>
</tr>
<tr>
<td></td>
<td>White Phase</td>
<td>White (W)</td>
</tr>
<tr>
<td></td>
<td>Blue Phase</td>
<td>Blue (B)</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>Black (BK)</td>
</tr>
<tr>
<td>Earthing</td>
<td></td>
<td>Green-Yellow (G-Y)</td>
</tr>
<tr>
<td>230 V AC control:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When supplied from the same compartment or SCA</td>
<td>Active</td>
<td>Brown (BN)</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>Black (BK)</td>
</tr>
<tr>
<td></td>
<td>Active</td>
<td>Orange (O)</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>Black (BK)</td>
</tr>
<tr>
<td>CTs &amp; VTs secondaries</td>
<td>Red Phase</td>
<td>Red (R)</td>
</tr>
<tr>
<td></td>
<td>White Phase</td>
<td>White (W)</td>
</tr>
<tr>
<td></td>
<td>Blue Phase</td>
<td>Blue (B)</td>
</tr>
<tr>
<td></td>
<td>Neutral</td>
<td>Black (BK)</td>
</tr>
<tr>
<td>Extra Low Voltage (AC or DC)</td>
<td></td>
<td>Light Grey (LtG)</td>
</tr>
<tr>
<td>Conductors connecting voltage free relay contacts where the voltage is undefined</td>
<td></td>
<td>Violet (V)</td>
</tr>
<tr>
<td>Sheath of double insulated cable for Intrinsically Safe circuits</td>
<td></td>
<td>Light Blue (LtB)</td>
</tr>
<tr>
<td>Instrumentation twisted pair conductors</td>
<td>Positive</td>
<td>White (W)</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>Black (BK)</td>
</tr>
</tbody>
</table>
ITEM | WIRING AND/OR CONDUCTORS | COLOURS
--- | --- | ---
Customer communications cable for connection to a carrier telecommunication network | Refer to AS 3000 and Telecommunications Cabling Provider Rules from ACMA |  

- Orange and violet would not normally be used, since all control wiring between switchboards or compartments should be extra low voltage.
- Extra low voltage includes wiring to thermistors, thermostats, etc.
- As an alternative for cables above 35 mm², and for all double insulated cables, phase identification shall be 25 mm wide heat shrink bands of the colours specified in this clause applied at each end.

All earth conductors shall be identified at each termination by the colour green or green-yellow. Other colours shall not be acceptable. Under no circumstances shall the colour green or green-yellow be used for other than earth conductor identification.

Each end of all conductors shall be identified with white thermoplastic interlocking ferrules with machine printed black and red characters. Ferrules shall be sized to fit conductor insulation and installed at every terminal. Each cable core shall be identified at the time of making off.

Where multiple devices performing similar functions (e.g. duty – duty pumps) are installed at the one site/SCA, the control wiring for each device shall utilise alternate phases.

### E9.7 Labels
A nameplate shall be fixed to the SCA with its designation. Location number from Maximo shall be included in the nameplates and labels.

Engraved circuit designation labels shall be fitted. Labels shall be installed on the outside of each starter, control panel and distribution panel identifying the function and / or the equipment being supplied.

Labels shall be fitted to identify all switchboard modules and electrical components mounted on/or within the switchboard.

Nameplates for individual modules shall contain module specific details such as kW rating and Australian Standard number.

Safety signs and danger labels shall comply with AS1319.

All covers over busbar chambers shall be fitted with danger labels. Such labels shall read 'DANGER LIVE BUSBARS UNDER COVER'.

Where 'LOW VOLTAGE' connections are mixed with 'EXTRA LOW VOLTAGE' connection on terminal strips they shall be identified with a suitable label.

All switches, fault current limiters, etc. not controlled by a main switch shall have a label adjacent to it marked 'NOT CONTROLLED BY A MAIN SWITCH'.

All designation labels shall be manufactured from white black white traffolyte or similar material, unless specified otherwise.

All lettering engraved on labels shall be in block capitals.

All labels for panel mounted electrical components shall be fixed to stationery structures adjacent to the particular item of equipment they identify with the working horizontal.

Where an item of equipment is removable or has a removable part, for example doors, covers, plug-in-relays and the like then the removable part shall be similarly identified.
The manufacturer's data plate shall be readily visible from an accessible position, or a duplicate label bay be attached to the fixed structure which complies with the above requirements.

The manufacturer's nameplate applicable to each overall unit shall include the following information:

- Manufacturer's name.
- Year of manufacture.
- Rated voltage.
- Rated frequency.
- Form of segregation.
- Degree of protection.
- Rated short circuit capacity.
- AS number to which SCA is manufactured and verified. (AS/NZS 61439 series).

Each starter shall be provided with a data plate on the inside of each module that shall display the following details:

- Manufacturer's name.
- Type of starter (i.e. direct-on-line, etc.).
- Rating of the starter in kW.
- AS number to which starter is manufactured (AS 60947.4.1).
- Rated duty and class (e.g. intermittent or continuous).
- Utilization category (e.g. AC-3).
- Control circuit voltage.

The data plate shall be made of non-corrosive metal plate with engraved inscriptions. The nameplate shall be fixed in position by M3 chrome plated screws, nuts and washers and shall be clearly visible from the access position.

### E9.8 Functional Units and Cable Zones

New SCA's shall be provided with 15% spare modules for future use. These modules shall be fully functional units equipped with take-offs, circuit breakers, fuses and equipment slide rails. The bottom module of each tier shall not be used or counted as spares if the control switches, meters and indication lights will be lower than 350 mm from the floor. If for any reason a module needs to be mounted lower than 350 mm from the floor, it needs to be a plug in type that can be completely removed for maintenance.

Ammeters and voltimeters shall be 96 x 96mm quadrant scale. Instruments monitoring the incoming feeder shall have selector switches that shall include an "OFF" position.

A 15 minute averaged maximum demand indicator, switchable between phases, shall be incorporated on the main incoming supply. The maximum demand indicator may be integral with the ammeter.

Each module shall have facilities for padlocking the main isolator in the "OFF" position with a standard padlock or a multi-locking device. Access to the interior of the module shall only be possible after power has been turned off.

All doors over 600mm in height shall be fitted with a 3-point locking mechanism.

All door and cover fastenings shall remain captive when the door is opened or cover removed. The use of "acorn" nuts or similar is not acceptable.

All normal access doors and covers shall be provided with neoprene sealing gaskets manufactured for sealing purposes. The use of foam plastic materials is not acceptable. Removable panels or covers shall be provided to give access to busbar zones. These panels shall not be hinged and shall be fitted with warning labels "DANGER - LIVE 400V BUSBARS". The labels shall be white lettering on a red background.
Cable zones shall be provided to route power and control cables to the functional units. Cable zones shall be minimum 400 mm width. Access shall be available to the cable zone for installation and maintenance work without exposing the busbar droppers. Cable entry into the cable zone shall be from below. Power and control cable connection points shall be located in the cable zones adjacent to the respective functional unit. The connection points shall be fully shrouded terminals and the need to terminate outgoing cables within the module is not acceptable.

All gland plates shall be 5mm thick aluminium with cable glands. Where single core cables are proposed, supporting clamps and cleats shall be non-magnetic.

E9.9 Surface Treatment and Painting Instructions

The interior and exterior surfaces of the cubicles, including the frame work, of the SCA and the control panel shall be treated and painted in accordance with WSA 201 and Sydney Water Supplement. This requirement applies for all materials including stainless steel.

Application of Protective Coatings

Colours shall be as follows:

Indoor:  
Interior - White;  
Exterior - Aqua (B25/AS2700)

Outdoor:  
Interior - White;  
Exterior - Dulux Ocean Mist 96183250 or European Colour Standard No. RAL 9018

Any change to the standard colours requires acceptance from Sydney Water’s technical and operational representative. This includes painted murals.

E9.10 Circuit Breakers

The designer shall select circuit breaker endurance ratings based on the load and expected mode of operation.

All circuit breakers shall comply with AS 60947.2. Circuit breakers for incoming feeders shall be air circuit breakers or moulded case circuit breakers with adjustable electronic protection relay capable to perform long time, short time and instantaneous protection elements (ANSI 50/51).

Circuit breakers for motor starters shall be moulded case circuit breaker with adjustable fault current protection. Moulded case air circuit breakers shall have positive physical indication of the "tripped" position. The circuit breakers shall be of the thermal magnetic type with the quick make, quick break, and trip free toggle action and fitted with efficient arc interrupting devices of the "de-ion" type. Contactors shall be of non-welding alloys and all metal parts shall be treated to prevent corrosion.

All circuit breakers shall be fitted with provision for locking in the 'OFF' position using a standard padlock or a multi-locking device.

E9.11 Surge Diverters

Suitable surge protection devices shall be supplied and installed to protect equipment against lightning strikes, motor starting and stopping or sudden loss or application of power supply. Surge protection devices shall be connected across the incoming power supply, individual instrumentation loops, PLC input/output and other lines that run external to the building and to instrument devices mounted on metallic structures i.e. pipes which are connected to the building.

The mains 400 V power supply connection points shall be capable of withstanding 5 kV positive and negative pulses applied between the input terminals and between each input terminal and earth with all metallic framework bonded together.
Minimum size surge protection earth cable shall comprise stranded, 6.0 mm², and green/yellow PVC insulated cable installed such that it is segregated from all other cables.

Equipment housed in the SCA shall be protected against mains voltage switching and lightning surges by shunt surge protection units installed on each incoming supply. Each surge protection unit shall be an enclosed three phase device including a number of semiconductor non-linear resistors, a combination of MOV shunt diverters and low pass filters to achieve required surge protection between phases, phase to neutral, phase to earth and neutral to earth.

The following minimum requirement shall apply:

- Modular construction to enable replacement of damaged module
- Multistage protection with indication of protection level remaining
- Automatic reset after clamping
- No stage failure for currents below 45kA
- Unit healthy indication and stage failure indication (for each stage in each phase) by LED's and mechanical flag on the unit
- Provisions for remote indication of stage failure by means of pre-wired auxiliary contacts. Each contact shall be rated at 1 A, 230 VAC/2 A, 24 V DC
- Mains supply voltage: 500 V rms, 50 Hz, 3 phase
- Maximum surge current: 135 kA (8/20 us waveform) or above
- Leakage current: 250 μA phase to earth
- Response time: < 10 ns
- Let through voltage: 875 V maximum
- Operating temperature: -10°C to +60°C
- Surge diverters shall be mounted so that they can be inspected whilst standing at floor level to determine if they are still active and they can be replaced whilst standing at floor level.

**E9.12 Phase Failure Relays**

Phase failure relays shall monitor all phases of the circuit they are protecting. The phase failure relays shall be adjustable to detect the reduction in any phase voltage over the range 40-95% of nominal voltage and operate with an adjustable time delay in the range of 0-5 seconds. The phase failure relays shall have voltage free contacts wired to readily accessible terminals. The relays shall be digital with a fixed time to trip that will not normally exceed 100 ms and under no circumstances will exceed 200 ms.

**E9.13 Panel Meters**

Ammeters and voltmeters shall be provided on the incoming feeder(s) to the switchboard. They shall be connected on the load side of the mains switch controlling the incoming feeder where only one main switch is employed. Where the switchboard has more than one incoming feeder, metering shall be provided on the line of all incoming feeders. For mobile and/or permanent generator connected feeder, there shall be separate voltmeters connected on both line side and load side of the main switch, and the ammeter for generator main switch shall be connect on the line side of the main switch.

Ammeters and voltmeters shall have an accuracy class of 1.5.

Ammeters shall be the direct reading type up to 30Amps. For currents in excess of 30Amps, a metering current transformer shall be provided.

Ammeters to read the motor current shall be suitably over scaled for starting current.

Ammeters and voltmeters shall be 96mm non-flush mounting, square pattern industrial grade instruments with a 90º deflection movement. Scales shall include a red mark indication of motor full load current.
The use of digital meters shall be acceptable subject to the acceptance of SWC.

**E9.14 Current Transformers**

Current transformers shall be class 1. They shall have a 1 amp or 5 amps secondary unless otherwise specified, and a minimum burden rating of 7.5 VA for metering.

The data plates of current transformers shall be readily visible from the access position. If the data plates of current transformers are not readily visible from the access platform an identical data plate shall be provided and fixed adjacent to the current transformers.

Protection current transformers shall not be used to supply metering circuits.

For multi-ratio current transformers, the class, output and burden specified shall apply to the lowest ratio.

**E9.15 Contactors**

Contactors shall comply with the following:

- Quiet in operation.
- Rated duty intermittent class 01.
- Utilisation category of “AC-3” or “DC-3” as a minimum, with higher categories considered for the application.
- Contact life of minimum 1 million no load operations.
- Minimum rating of 16 A, 400 V at category ASE204.
- Be designed to allow for fitting of auxiliary contacts with rating of 4A at 230V AC.
- Minimum of 2 N/O and 2 N/C contacts.
- Minimum coil burden of 6 VA while holding

**E9.16 Motor Over-temperature Relays**

For motors 5.5 kW and over, starter modules shall be equipped with an over temperature relay(s) suitable for use with PTC thermistors supplied with motors.

The over temperature relay shall be provided with auto reset and shall trip when the temperature in the motor exceeds the operating temperature.

The whole motor temperature protection system shall not latch out in case of power failure, i.e. it shall not prevent the starter from restarting the motor when power is restored.

**E9.17 Motor Protection Relays**

All motors shall be protected from overload, phase unbalance and faults with motor protection relays. Motors less than 75 kW shall be fitted with bimetallic thermal overload relays. Motors 75 kW and above shall be fitted with electronic motor protection relays with the following features:

- Thermal overload with pre-alarm
- Undercurrent
- Single phasing and unbalance
- Under-voltage
- Earth fault
- Panel-mount status and alarm display
- Load current and power factor display
- Thermistors input channel
- Programmable output relays
• Front panel operator interface
• Capable of communicating treatment plant SCADA system and shall be in accordance with the Treatment Plant SCADA Standards and associated standard template drawings and schematic diagrams.

**E9.18 Auxiliary Relays**

Relays used in LV starters and LV switchboard shall be DIN rail mounted, they shall have flat pin design, test button, LED indication. The relays selected shall have cross compatibility with other manufactures’ relays and/or base.

The relay shall have no less than the mechanical endurance of the contactor and in any case no less than a mechanical life of 1 million operations.

Contact ratings shall be a minimum of 5 Amps at 230 V and shall be capable of carrying the inrush and hold-in current of the associated controlled device, e.g. contactor, heater, etc.

Relays shall be operable, as a minimum, over the range 80% to 110% of the nominal voltage.

Relays forming part of 24 V DC control circuits shall be fitted with overvoltage suppression diodes.

Attention is drawn to the need to consider the impedance of the auxiliary relays when long cable runs (exceeding 100m) are used for emergency stops and field stop/start buttons. Miniaturised relays may have sufficiently high impedance for cable capacitance to induce malfunction and should there be avoided. It shall be demonstrated to SWC satisfaction that the design accommodates this consideration.

**E9.19 Timers**

All timers shall be of the electronic plug-in type, which permits removal of the timer body without disturbing the connecting wiring.

Timers forming part of 24 V DC control circuits shall be fitted with overvoltage suppression diodes.

Dashpot, pneumatic or thermal type timers will not be permitted unless prior acceptance is given in writing.

**E9.20 Fuses**

Fuse holders (bases and carriers) and fuse links shall comply with AS/NZS 60269 and AS 61818. Fuse holders shall be fully shrouded.

All circuits, including starters potential and control circuits, shall be protected by HRC fuse links.

**E9.20.1 Fault Current Limiting Fuses**

Fault Current limiting fuses can be used to reduce the incident energy by reducing the available fault current. If fault current limiting fuses are chosen for mitigation, an additional design is required to ensure the high fault current cannot be applied to the downstream devices. The design will need to show all calculations to ensure the fault limiting fuses are carrying out their intended use. The design is subject to prior acceptance from SWC.

**E9.21 Indicator Lights**

Indicator lights shall be:

• LED type for 230 V AC and 24 V DC.
• Illuminated when a lamp test button is operated.

All lamps shall have Miniature Bayonet Cap (Ba 9).
E9.22 Variable Speed Drives and Electronic Soft Starters

E9.22.1 Variable Speed Drives (VSDs)
The variable speed drive units shall incorporate the following features and design functions:

- Matched to suit the three phase ac squirrel cage induction motor and load torque requirement of the driven unit in the whole speed operating range.
- Capable of operating continuously as their nominated full rating with expected variations of +/-10% in supply voltage and +/-2% in supply frequency.
- Capable of withstanding 110% of full current for 60 seconds.
- Capable of allowing 110% starting torque for quadratic torque drives. Where required for constant torque drives (conveyors, mono pumps, etc), the starting shall be capable of supplying up to 160% starting torque.
- Required to operate at speeds as low as 20% of full speed whilst providing the necessary load torque at these speeds and without cogging, overheating or otherwise damaging the motor.
- Capable of setting up three different ramp rates for acceleration and deceleration. Ramp rate selection shall be programmable within the VSD and speed dependent. The use of external tachometer is not acceptable.
- Manufactured in accordance with ISO 9001 standards and C-tick approved;
- Have a fundamental power factor of at least 0.95 and a total power factor of at least 0.9 at full load.
- Have an efficiency of better than 0.96 at rated power.
- Have output filters that limit the peak voltage and rate of voltage rise to comply with IEC 60034-17.
- Output current waveforms shall be sinusoidal and as such no motor de-rating shall be applied when operated at rated speed and load.
- Acceleration and deceleration time shall be fully adjustable.
- Automatic slip adjustment of output frequency and voltage speed for regulation from 0 to 100%.
- Digital and relay outputs for alarm and status signals.
- Protection for current and voltage faults and motor thermal overload:
  - Failure to connect a motor to the VSD output.
  - VSD output open circuit that may occur during operation.
  - Single-phase fault or three-phase short circuit on VSD output terminals.
  - Failure to commutate inverter thyristor due to severe overload or other conditions.
  - Loss of input power due to opening of VSD input disconnect device or mains power failure during VSD operation.
  - Loss of one (1) phase of input power.
  - Motor regeneration due to "turbining" or loss of VSD input power.
  - Motor overload protected by modelling the operating characteristics of the motor.
  - Motor overload protection by accepting inputs from thermistors embedded in the motor winding.
- With electronic shear pin capability for process drive that requires shear pin protection;
- Digital inputs to select two programmable pre-selected speeds;
- Alarm, trip signals and display signals for:
  - under voltage
  - over voltage
  - over current
  - under current
  - frequency converter temperature
motor over temperature
motor fault - short circuit and earth fault

- The communication protocol capabilities shall be according to Treatment Plant SCADA standard and associated standard templates drawings and schematic diagrams.

**E9.22.2 Electronic Soft Starters**

Soft start starters shall be used for acceleration and deceleration of motors. For motor of rating under 75kW the soft starter shall be suitable for on-line operation without bypass. For motor rating of 75kW and above the soft-starter shall incorporate bypass operation after start up. The bypass operation shall be achieved without affecting the monitoring and protection functions of the soft starter.

The starters shall comprise of:

- A three phase air break contactor Category AC-4 to provide isolation.
- Enclosed fuses to protect the semi-conductor module - one (1) per phase.
- A semiconductor module to accelerate and decelerate the motor. The module shall include internal control and self-protection.
- An electronic relay or thermal overload relay to protect the motor.

The semiconductor module shall be of closed loop type and shall have six (6) silicon controlled rectifiers (SCRs) in a full wave bridge power circuit.

The SCRs shall have a minimum PIV (peak inverse voltage) of 1200 volts. The SCRs shall have a rated starting duty of 6 full load current starts for 30 seconds.

The starter shall have an adjustable start up torque setting and adjustable voltage ramps for acceleration and deceleration. The acceleration and deceleration voltage ramps shall be adjustable independent of each other.

The initial start-up torque setting shall have an adjustable range of 20-100%.

The acceleration voltage ramp shall have a range of 5-30 seconds and the deceleration voltage ramp shall have a range of 5-60 seconds.

During a controlled run-down deceleration, the motor current shall be limited to a value below that of the starting current.

The starter shall be suitable for three (3) phase induction motors.

The starter shall withstand external electrical influences both current and voltage transients.

**E9.22.3 Other Requirements**

**EMC**

It is a requirement that VSDs do not interfere with the communications and instrumentation signals. Electromagnetic interference emitted by the equipment shall be within the limits stipulated by the Australian Standards/electricity distributor. Full installation instructions for the equipment, referring in particular to electromagnetic interference reducing practices shall be provided in clear English text. Noise suppression filters, if required to meet EMC Standards, shall be supplied. Screened power cables shall be used for VSD's.

EMC Filters shall be provided on each VSD to meet the Australian Standards and electricity distributor requirements and conform to the limits specified in the First environment with restricted distribution, tested to minimum 100 metres screened motor cable.

**Harmonics**
1. Where VSDs are utilised on the site, a harmonics distortion measurement shall be performed up to 50th harmonics on the site power supply at the point of common coupling (PCC) within 6 weeks of the commencement of the concept design. The result of the measurement shall be included in the Concept Design Report. On completion of the same tests shall be completed with the maximum number of VSDs running. These results shall be submitted to the SWC 2 weeks after completion. The Report shall contain all measurements, supporting calculations, diagrams and information. Prior agreement with SWC shall be obtained based on the conditions for determining the THD prior to undertaking the measurements including:
   i. Duration of the measurement period (Minimum of seven days)
   ii. Time of day of the measurement period
   iii. Measurement of baseline harmonic levels (without VSDs in operation)
   iv. Measurement of harmonic levels shall be taken with maximum number of drives running
   v. Positioning of measurement equipment
   vi. Type of measurement equipment
   vii. Format of the Report of the results

2. Harmonic filter(s) shall be designed, supplied and installed as required to bring the level of harmonics distortions to within levels as required by Australian Standards and to meet the electricity distributor’s requirements.

3. New VSDs shall be designed to comply with the limitations on harmonic contribution as required by Australian Standards and to meet electricity distributor’s requirements.

4. In selecting the drive technology and harmonic mitigation options, it is to be ensured that the total harmonic distortion in voltage contributed by the VSDs at the point of reference for the plant is limited to an acceptable maximum value of the fundamental. Liaison with the electricity distributor is required to determine the acceptable maximum value.

5. In addition to item (d) above, a VSD solution shall be provided that will have a 5th harmonic current component which will allow Sydney Water to meet the 5th harmonic current allocation of an acceptable maximum value (amperes) for the whole site as specified by the electricity distributor.

6. Unless otherwise specified, the point of reference for all harmonic calculations and field measurements for both voltage and current distortion shall be taken to be from the supply cables of the main HV switchboard.

7. All harmonic mitigation measures including any additional harmonic filtering equipment must meet the specified harmonic distortion and allocation limits specified herein.

The harmonic filter must provide harmonic filtering for all loads connected to the SCA for all SCA bus configurations.

**Radio Frequency Interference (RFI)**

It shall be ensured that operation of the starter shall not produce the following:

- RFI back to the main supply network.
- RFI which is radiated into the atmosphere.
- RFI which may affect any of the devices in the starter.

**Semiconductor Module Protection**

The following minimum protection features are to be built into the electronic circuitry of the semiconductor module:
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- Phase loss.
- Incorrect phase sequence.
- Phase imbalance.
- Thermal protection on SCR heat sink.
- SCR protection against short circuits using fast acting HRC fuses protection for SCR.
- A metal oxide varistor and capacitor protective unit shall be provided to absorb voltage surges from the supply network.
- Overload.
- Under voltage.
- Under load.

When any of the above protection items operate, a common fault light shall be maintained, the motor shall be disconnected from the supply voltage and remain locked out of service until manually reset.

However, should the thermal protection on the SCR heat sink operate, a separate fault light shall be activated and the motor shall then be allowed to automatically restart providing the external automatic control circuit requires that to occur.  This fault shall bring up a ‘General Fault’ light on the Starter Panel.

Appropriate wording of fault indication lights and reset labels shall be provided.

RCD Protection for VSD Circuits

Section E2.16 specifies the requirements for directly connected VSDs.

For VSDs that are connected via socket outlets, the circuit must have VSD compatible RCD protection.

E9.23 Control cubicles

The control cubicle shall be suitable for use on a 24VDC control system, unless specified otherwise.

The cubicle shall be constructed to comply with AS 61439.1 and shall be of the indoor, free standing, enclosed metal clad type, suitable for housing of control and communication equipment.

The degree of protection shall be IP52 to AS 1939. All cubicles shall be dust and vermin proof, including the bottom and cable entries.

The segregation for the Control Cubicle shall be Form 1. Control and communications equipment and cabling within the control panel shall be segregated from the power equipment.

A 12 W LED light, automatically operated by a door switch, shall be provided in each panel.

All panels shall be constructed from 2 mm (minimum) CRCQ mild steel with adequate supports to withstand mechanical stresses during transport and installation and at times of electrical faults. If there are any welds they shall be continuous. Tack welding will not be accepted.

Each transport unit shall be adequately rigid to enable lifting from above and handling during storage, transport and installation, and to permit the use of rollers for final location. Lifting eyes shall be provided.

All other requirement shall be as per Low Voltage SCA requirements.

E9.24 Auxiliary Distribution Boards

Auxiliary distribution boards must be constructed in accordance with AS 61439 series. Cabinet shall be IP42 for indoor installations (IP66 for outdoor), and have a main hinged door with a 3 point latch type locking system keyed with an 8mm square drive. Cable entry to auxiliary distribution board shall be via bottom only. All metal part of the cabinet shall be bonded to earth. The cabinet shall be painted to N42 storm grey or RAL 7032, and N14 white interior. Consideration should be given to use SS 316 in natural finish when the auxiliary distribution board is installed at SPSs and STPs.
General light and power distribution boards shall be an encapsulated chassis type, with rail mounted circuit breakers. Where specified, shall be able to house essential lighting, changeover contactors and ancillary equipment.

Where dual supply is required, changeover switch and phase rotation (for three phase boards) shall be fitted.

Earth and neutral bars shall be double screw type and sized the same cross-sectional area as active phase conductors.

An escutcheon plate shall provide IPxxB protection to allow operation of the circuit breakers, main isolator and changeover switch. This shall be secured by captive screws requiring a tool for removal (i.e. no knurled knob type fittings).

All devices that may be isolated shall have the ability to fit standard lock out – tag out equipment. Individual circuits shall be able to be isolated with the escutcheon panel in place.

A minimum of 20% spare poles shall be provided. The spare poles shall be fitted with pole fillers.

All labels shall comply with Section 9.3 of this specification. The cabinet shall have an external stainless steel label with black etched writing. The label shall clearly identify the name of the distribution board, drawing number and source of supply.

Final subcircuits shall be identified by either:

a) screwed on traffolyte labels with black lettering on white background or;

b) a type written schedule, protected by plastic or glass and fixed to the back of the DB door.

### E9.25 Measurement and Signal

Each SCA shall be fitted with suitable metering equipment and devices so that the signals specified in the Treatment Plant SCADA Standards and associated standard template drawings and schematic diagrams are made available to SCADA. The signal shall be transferred via a digital/serial communication to the plant SCADA system.

If the Treatment Plant SCADA Standards are not applicable,

The following signals shall be made available:

- Current
- Voltage
- Power factor
- Frequency
- Power kW
- Maximum demand kW
- Reactive Power kVAR
- Fault Current Interrupted
- Closed/open (from circuit breaker auxiliary switches).
- Power supply healthy/failed (from phase failure relay connected to the secondary side of voltage transformer on incomer or busbar).
- Protection relay operated (from circuit breaker trip relay).
- Trip circuit healthy/failed (from trip circuit supervision relay or trip circuit supervision output of main protection relay).
The phase failure relay and incoming circuit breaker(s) status-monitoring device shall be fitted with minimum two voltage free changeover contacts wired out to a segregated set of labelled terminals in a cable and terminal zone. These shall be connected to a PLC and displayed, monitored and logged on the SCADA.

All electricity distributor metering circuits and equipment must be in accordance with the electricity distributor service rules.
E10 Low Voltage Power Factor Correction Unit

E10.1 General

Bulk power factor correction equipment shall be located in the main power distribution centres for the Plant and be integrated into the existing plant power distribution system. The switching steps shall be designed to ensure that the power factor shall not be leading at any stage.

This clause sets out the general requirements for low voltage power factor correction units. The requirements of high voltage power factor correction units are covered in Clause 5 and the specifications listed therein.

The capacitors and the associated equipment shall either be housed inside the individual designated areas, which form part of the starter / SCA or in a separate cubicle. All required interconnections between the starter / SCA and capacitors (including fuses, filter chokes, etc.) shall be provided. The power factor correction unit must provide power factor compensation for all loads connected to the SCA for all SCA bus configurations.

If required, capacitors shall be provided with an external fuse of the current limiting type in each phase. The fuse shall be suitable for use in air and shall be provided with a striker pin.

All test results shall be submitted as evidence of performance.

E10.2 Enclosure

The power factor correction cabinet shall have the following features:

- Manufactured on a minimum 2mm sheet steel and powder coated to a paint thickness of 70 micron.
- Door to have lift off type hinges and lockable with special keys. The hinges shall be chrome plated pintle type
- Up to 900mm high shall have 2 hinges
- Up to 1200mm high shall have 3 hinges
- Equal to or greater than 1200mm high shall have 4 hinges.
- Free standing, front access.
- Vermin proof.
- IP rating of 54 (IP52 if installed in air conditioned switchrooms).
- Well ventilated with thermostat-controlled fans.
- A separate cubicle for detuning reactors with nonmagnetic mounting brackets.
- All live components shall be shrouded such that no live parts are accessible from the front of the enclosure with the door open.
- Terminals for all internal components shall be accessible from the front of the cubicle (with shrouds removed).

E10.3 Painting

The surfaces shall be painted after all forming operations (including cutting, folding, punching) and welding of the sheet steel.

All selected paints must be applied strictly in accordance with the manufacturer's instructions.

The finish colour shall be:

- Interior: white
- Exterior: aqua B25
E10.4 Capacitors
Capacitors shall comply with the requirements of AS/NZS 3000 and the New South Wales Service and Installation Rules.

Each capacitor unit shall:
- Be rated for connection to a 400V, 50Hz supply and where used with detuned (blocking) reactors, shall be rated at a minimum of 525V.
- Be three phase.
- Be low loss dry type with self-healing dielectric. Maximum loss 0.5W/kvar including resistors. Capacitor impregnated with liquid or gel will not be accepted. Non-biodegradable impregnating liquids such as polychlorinated biphenyls [PCB] or askarels will not be accepted as a dielectric medium.
- Be fitted with discharge resistors.
- Be suitable for operation in ambient temperature of 0 to 50°C.
- Be capable of withstanding 30% overcurrent (continuous) and 30% overvoltage (1 minute).
- Have a design life of 15 years minimum.

E10.5 Reactors
Reactors shall comply with the Australian Standards. Type test certificates shall be available on request.

The reactors shall:
- Be rated for series connection in a detuning circuit tuned to 189 Hz, for operation on a 400V 50 Hz supply.
- Be dry type air cooled with high permeability silicon grain oriented laminated core.
- Be of insulation class H.
- Have dielectric strength of 3 kV for 1 minute.
- Have Q factor of 38.
- Have flux density less than 0.8 Tesla.
- Have winding temperature rise of less than 40 degrees.

E10.6 Control Relay
The unit shall be fitted with an automatic power factor control relay mounted on the front door of the cubicle. The relay shall include the following features:
- Suitable for connection to and control of 400V, 50Hz 3 phase 4 wire supply,
- Suitable for use with the current transformers and summation transformer supplied to measure power factor,
- Minimum six stage switching,
- Adjustable power factor setting need to make sure not to have leading power factor,
- Adjustable starting current setting,
- Automatic disconnection of all capacitors in case of power outage,
- Programmable time delay for switching between stages,
- Selection of manual or automatic operation,
- Circular switching to share equal duty of capacitors,
- Digital display of power factor, volts, amperes, active and reactive power, number of capacitor stages in use,
- Alarm output for unit failure and over temperature.
E10.7 Isolation of power factor correction unit

Isolation of power factor correction unit shall comply with Service and Installation Rule NSW. The power factor correction unit shall be isolated by a fault make, capacitive load break switch, it is not acceptable to use a fuse link or the power factor controller to operate capacitor contactors to provide isolation.
E11 Low Voltage Motors

E11.1 General
The motor and the driven unit torque speed curves shall match to ensure smooth, positive starting, in conjunction with the starter used, under all operating conditions.

Motors driven by variable speed drives shall be specially designed for use in variable speed operation. They shall be so rated and capable of operating over the entire speed range without exceeding its normal operating temperature. Additional fan forced cooling are not acceptable to achieve the required cooling.

Each motor shall be fitted with lifting lugs or eyebolts.

The rated speed of the motors shall suit the requirements of the driven units and shall not be greater than 1500rpm (nominal).

For motors 100kW and above, illustrations and drawings giving complete motor winding diagrams and a diagram of connection for every coil showing terminals, wire sizes etc. shall be provided.

E11.2 Motor sizing for water and sewage pump stations
When requested for pump stations in network installations, the power of the motors shall be 15% greater than the maximum power required up to 110% of the duty flow rate to ensure adequate motor life expectancy under all working conditions.

The motors shall also be non-overloading at minimum (flood) head condition. The motor rating shall be sufficient to ensure that the motor will not overload when the pump is discharging through the pressure relief valve at all speeds down to the minimum allowed as specified by the pump supplier.

In the event of failure of a duty unit, the next available pump shall be automatically activated after an adjustable time delay.

In order to reduce the wet well operating volume and control levels, the electrical equipment shall be capable of minimum 8 starts per hour for each pump.

E11.3 Motor
Each motor shall have an enclosure protected against driving rain (IP56) enclosure including any necessary internal or external ventilating fan.

There may be some applications where there is specific motor sizing requirement. Refer to the Mechanical Specification when this is applicable.

Submersible motors shall be IPX8 and fitted with moisture detection in the motor stator housing and the cable termination housing. Pump seal failure detection shall be provided for motors of size 7.5kW and above. Submersible motors shall be fitted with cable of sufficient length connecting directly to the starter or to above ground turret/s to suit the application and the requirements of the project. Cable shall be suitable for use under water and shall have an outer sheathing to protect it from damage. The cable shall also have a stranded 316 stainless steel supporting cable, which shall be anchored at each end to protect the motor terminations from damage whilst pump motor is being removed from its sump. Additional cores for the thermistors shall be provided as required or a separate cable shall be supplied for thermistors. The turret/s shall be installed adjacent to the wet well and shall be accessible without entering the wet well. There should be one turret per motor and each turret should have a back plate for mounting "suitable" size terminals, which are shrouded. The terminals shall be stud type. In addition, the back plate is required for mounting smaller terminals for the motor condition monitoring cables i.e. thermistor, seal etc.

Motors operating in corrosive conditions shall have an anti-corrosion finish.
Each motor shall be manufactured in accordance with the latest issues of AS 60034 series. The motor shall have Class F winding insulation for Class B temperature rise, shall be maximum continuous rated and shall be capable of at least 12 starts per hour when coupled to the driven unit. The motor’s maximum starting (locked rotor) current at rated voltage at 50 Hz shall not exceed 7 times the rated full-load current.

The continuous rated output of each motor shall be at least 15% in excess of the maximum power required by the driven unit under all specified operating conditions.

Motors with a rating between 0.73kW and 185kW shall be "high efficiency" motors complying with minimum efficiency requirement as specified in AS/NZS 1359.5.

Motors with a rating 185kW and above shall have a minimum efficiency of 96%.

Motor condition monitoring requirements must comply with the Bearing Condition Monitoring for Large Machines as specified in the Mechanical Specification.

**E11.4 Terminal Boxes**

Terminal boxes shall be of adequate dimension to allow the motor to be wired up in air with suitably rated PVC insulated and sheathed single three core cables in compliance with AS/NZS 3000. The motor windings shall be brought out to suitable fixed terminals, preferably stud type, located within the main terminal box.

An earthing stud shall be provided on the motor frame or in the main terminal box.

For submersible motors, all cables entering the motor shall be glazed to a single demountable flange.

**E11.5 Bearings**

Electric motor bearings shall be self-lubricating ball or roller types of standard design. Grease lubrication is preferred. A roller bearing shall be fitted at the driving end. A self-aligning thrust race shall be fitted, or alternatively a dual purpose race may be used. This bearing assembly shall be retained on the motor shaft by a suitable locking device. The bearing shall be so constructed as to prevent a longitudinal displacement of the rotor in either direction due to external forces.

Motor bearings shall be insulated in a manner to prevent circulating currents from passing through the bearing surfaces. At locations where the bearings are insulated from the frame precautions shall be taken to ensure that any insulation is not short-circuited during motor assembly. The driving end bearing shall be earthed via a removable copper shunt.

**E11.6 Motor Testing**

These tests shall be carried out by the manufacturer at his works, and standard certified test sheets shall be supplied before the motors are delivered.

Each motor shall be routine tested, in strict accordance with the Australian Standards.

**E11.7 Temperature Protection**

For motors of 5.5kW and above, at least one [1] temperature sensing device of the PTC semiconductor type shall be embedded in each of the three [3] phases of each motor winding.

The requirements of bearing temperature protection for large motors (600kW and above) are covered in Sydney Water Part 2 - Mechanical Specification Section M5.

For motors smaller than 600kW, resistance temperature devices (RTD) and/or thermal switches shall be provided on the motor winding and/or bearing when specifically requested by SWC.
Unless specified otherwise, the wiring of the winding/bearing temperature devices shall be in accordance with the Treatment Plant SCADA/IICATS Standards and associated standard template drawings and schematic diagrams.

All thermistor/Pt100 leads shall be brought out to fixed, identified terminals in a terminal box separate from the main terminal box and series connected within the terminal box.

Every temperature sensing device of each group shall actuate a compatible tripping relay for its particular speed at a tripping temperature of 130°C for Class E insulation, 140°C for Class B insulation and 160°C for Class F insulation. The resistance of each device supplied shall be 1000 ohms at the tripping temperature, as specified above, for the class of insulation employed.

In addition to the nameplate of the motor, a nameplate shall be provided on the motor frame, bearing the following PTC device information:

- Maker.
- Type Number.
- Tripping temperature, °C.
- Resistance of each PTC device at the tripping temperature.
- Number of PTC devices embedded per motor.


E12 Electrical Actuators

E12.1 General

This section covers electrical actuators for valves and penstocks. Actuators shall be rated for continuous operation and shall perform to the Specification when operating within the whole range of ambient temperatures and relative humidity. Actuators installed outdoors shall be rated for operation in direct sunlight and exposed to most severe weather conditions. In addition, actuators installed in sewage pumping stations and sewage treatment plants shall have corrosion protection for aggressive sewage atmosphere with high humidity and high concentration of pollutants.

The maximum number of starts per hour shall not be less than 20 for part turn actuators and not less than 50 for multi-turn actuators. Actuators used for modulating duty in automatic control systems shall have a maximum number of starts per hour of not less than 1000 in ambient air temperature of 45°C and without shade. If a shade cover is required to meet this specification it shall be provided.

Actuators shall be capable of both electric motor operation (normal) and manual hand wheel operation (emergency). Only one mode of operation, either electric or manual shall be possible at any one time.

The actuator and gearbox assembly shall be designed to seat, unseat and rigidly hold the valve/penstock in any position between fully open and fully closed under all operating conditions without creep or flutter.

Actuators and gearboxes shall be rated, designed and sized to safely operate over the full range of valve/penstock operating conditions. The actuator and gearbox combination shall be capable of providing at least 30% torque in excess of the maximum torque required for seating, unseating, or emergency flow operation of the valve/penstock for the performance requirements specified. The actuator and gearbox shall be capable of sustaining the actuator stalling torque in the event of torque switch failure.

The normal opening and closing times of the valves of same type and size supplied for the same project shall be equal and adjustable. Unless otherwise stated in the Project Specific Specification, the open-to-close and close-to-open times shall be:

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>Open-to-Close/Close-to-Open Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to DN200</td>
<td>20 – 30</td>
</tr>
<tr>
<td>DN250 – DN400</td>
<td>60 – 90</td>
</tr>
<tr>
<td>DN450 – DN900</td>
<td>180 – 270</td>
</tr>
<tr>
<td>DN1000 – DN1200</td>
<td>300 – 450</td>
</tr>
<tr>
<td>Larger than DN1200</td>
<td>500 – 750</td>
</tr>
</tbody>
</table>

For positioning valves the movement speeds shall be specified in the project specific specification.

The opening/closing time for penstocks shall be as specified in the project Specific Specification.

E12.2 Mechanical Requirements for Electric Actuators

E12.2.1 General

The actuators shall be installed on the top of the valve/penstocks or valve pedestals (extension spindle shrouds) and shall be capable of being rotated through any 90° quadrant as a complete unit.
The actuator shall be of the heavy industrial design with cast iron or aluminium housing, "O" ring seals and captive screws on access covers which are regularly removed for adjustments.

Mechanical limit stops for the actuator gearbox shall be on the input side of the drive and not the output shaft.

All external nuts, bolts, washers, studs and screws shall be grade 316 stainless steel.

The actuator shall include as one integral unit the electric motor, reducing gearing, drive coupling, torque switches, position limit switches, gear case and auxiliary hand wheel. The valve/penstock and actuator combination must be self-locking.

The actuators shall have name plates with the following markings:

- Manufacturer's name
- Model and series number
- Year of manufacture
- Motor kW rating, speed, voltage, no. of phases, max. current, power factor and class of insulation
- Maximum operating output torque
- Output speed
- IP Rating
- Hand wheel ratio

The information shall be shown on an engraved stainless steel nameplate, permanently attached to the actuator using stainless steel fixings or adequate permanent adhesives.

E12.2.2 Gears

Reduction shall be accomplished by means of spur, helical, bevel and/or worm gears. The actuator shall have bronze or cast iron worm wheel and hardened steel worm gears that operate in a lubricant.

The gear reduction unit shall be a sealed unit, lubricated for life with suitable grease.

E12.2.3 Bearings

All gears and shafting shall be supported on antifriction bearings. Where thrust is a consideration, roller or axial thrust needle bearings shall be provided.

E12.2.4 Lubrication

All gearing and bearings shall preferably be grease lubricated. Seals shall be provided at all shaft penetrations of the gear case to prevent leakage of lubricant.

E12.2.5 Hand wheel

The actuator shall be equipped with a hand wheel for manual operation. The hand wheel drive shall be connected by means of a clutch mechanism, which also declutches the electric motor drive. The mechanism shall make it impossible for the motor and the hand wheel to be connected to the transmission at the same time. On motor start the hand wheel shall be automatically uncoupled.

The hand wheel shall have an arrow and the word "OPEN" or "CLOSE" indicating the required direction of rotation. The hand wheel shall operate in the clockwise direction to open and the anti-clockwise direction to close.

The actuator shall be self-locking whilst in either the motor drive mode or the hand wheel mode. Engaging valve/penstock for operation of any of these modes shall exclude operation by the other mode.
Should the actuator seat on very high torque or stall then it shall be possible to engage manual mode easily and without inducing any additional mechanical stresses in the actuator internals nor limit switch mechanism.

The maximum force required to operate the hand wheel to overcome valve/penstock normal running torque shall not exceed 160 N at the hand wheel rim.

The hand wheels shall be positioned as specified in the Technical Specification Part 2 Mechanical Works.

E12.2.6 Mechanical Position Indicator
The actuator shall be fitted with a mechanical position indicator in a shape of a mechanical pointer and dial to show closed through to open position.

E12.2.7 Durability
The actuator shall be designed to have a life of a minimum of 10,000 open/close/open cycles or 1,000,000 output drive sleeve turns. Actuators on modulating duty shall be capable of 1000 starts per day average with a ten year life.

E12.3 Electrical Requirements for Electric Actuators

E12.3.1 General
The actuator shall have integral motor starter unless otherwise specified in the Project Specific Specification.

The actuator shall preferably operate on a 400V, 50Hz, 3-phase power supply. However, for small size actuator where 230V single-phase, 50Hz is the standard model, 230V single-phase model is acceptable.

Unless otherwise specified in the Project Specific Specification, the actuator, motor, limit and torque switches, and associated control equipment shall have degree of protection IP68 in accordance with AS60529, suitable for immersion in 5 metres of water for 72 hours.

Integral actuators shall be of modular design, with a modular plug-in integral reversing starter, motor and either multi-plug or terminals for the cables. The integral reversing starter shall be modular in that it may be easily retrofitted to an existing actuator in the field.

For Hazardous Area installations, the actuator and motor shall be rated enclosure protection Class explosion-proof Exd.

For SCADA control application, Profibus interface communication for monitoring and control of the actuators, shall be provided within the plant SCADA network in accordance to the Treatment Plant SCADA Standards.

E12.3.2 Duty Rating
The actuator and motor shall be rated for a minimum of three (3) continuous closing and opening operations and have the following minimum duty rating in accordance with IEC60034.1:

For 2 position actuators: Duty Type S2 -15 minutes
For modulating actuators: Duty Type S4 -25%

E12.3.3 Integral Motor Starter
The integral starter shall be either contactor or semiconductor, Direct-On-Line, or variable speed, reversing type, electrically interlocked and complying with the requirements of AS60947.4.1 and AS60947.4.2 respectively and shall meet the following requirements:

1. Duty-uninterrupted and intermittent Class 0.1;
2. Utilisation category: - AC3 for contactor type;
   - AC53b for semiconductor type;
3. Minimum number of no-load operating cycles 10 million;
4. Be rated to enclosed operation.

**E12.3.4 Restoration of Control after Power Failure**

The system shall not latch out in case of a power failure, i.e. when power is restored all circuits shall be automatically returned to a state which allows the valve/penstock to operate normally and alarms to be reset.

Under "FIELD", “LOCAL”, “L1” and “L2” control, upon restoration of power, the valve/penstock shall stay still pending receipt of an "OPEN" or "CLOSE" instruction.

Under “AUTO” control, upon restoration of power, the valve/penstock shall move in accordance with the requirements of the control signals.

Notwithstanding the restoration of power, the motor overload and motor over temperature alarms shall not be automatically reset.

**E12.3.5 Fault Condition for integral actuator**

Voltage-free contacts rated at 0.5A, 24V DC shall be wired to the plug/terminals for remote indication for the following fault condition:

- COLLECTIVE FAULT (VALVE/PENSTOCK FAILURE)

The collective fault signal shall comprise the following faults registered by the actuator logic and transmitted via a changeover contact wired to the plug/terminals on the actuator:

- POWER FAILURE
- INCORRECT PHASE SEQUENCE
- PHASE FAILURE
- THERMAL SWITCH TRIPPED
- TORQUE SWITCH TRIPPED

**E12.3.6 Limit Switches**

The valve/penstock shall be stopped at the required position at each end of travel by limit switch/electronic signal. Limit switches not forming an integral part of the actuator are not acceptable.

In cases where the actuator manufacturer specifically recommends a different method of normal stopping and emergency lock-out stopping of the valve/penstock, the manufacturer's recommendations shall be submitted for acceptance.

The limit switches shall be geared to the drive mechanism and in step at all times whether the unit is operated electrically or manually. The switches shall be of the field-adjustable type capable of being set either fully open, fully closed, or at any intermediate position.

Limit switch gearing shall be appropriately lubricated and totally enclosed to prevent entrance of foreign material or loss of lubricant.

Limit switches shall be mounted so that the settings are not disturbed when cable connections are made or when the hand wheel is operated.

Limit switches shall be able to be adjusted from the front of the actuator.
The limit switches shall be totally sealed and permanently wired to prevent ingress of moisture. There shall be no bare contacts that the technician can accidentally touch whilst adjusting the actuator.

The limit switch shall be made of brass. Plastic switches will not be acceptable unless prior acceptance has been given by SWC.

The limit switches shall be voltage-free contacts rated at 0.5A, 24V DC shall be provided and wired to the plug/terminals.

For SCADA applications, the contacts shall operate directly from the above integral limit switches/electronic signal as follows:

1. One contact which shall close when the valve/penstock is in the fully closed position;
2. One contact that shall close when the valve/penstock is in the fully opened position.

For IICATS control systems and other applications, unless otherwise specified in the Project Specific Specification, the number of limit switches and assignable control functions required shall be as given in the table below.

### INDIVIDUALLY ASSIGNABLE LIMIT SWITCHES (NON-SCADA CONTROL)

<table>
<thead>
<tr>
<th>Item No</th>
<th>Number Of Assignable Switches</th>
<th>Assigned Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>One (1)</td>
<td>Actuator Common fault</td>
</tr>
<tr>
<td>2</td>
<td>Three (3)</td>
<td>Fully Opened</td>
</tr>
<tr>
<td>3</td>
<td>Three (3)</td>
<td>Fully Closed</td>
</tr>
<tr>
<td>4</td>
<td>One (1)</td>
<td>Opening</td>
</tr>
<tr>
<td>5</td>
<td>One (1)</td>
<td>Closing</td>
</tr>
<tr>
<td>6</td>
<td>One (1)</td>
<td>Control disabled (refer Note 1 below)</td>
</tr>
</tbody>
</table>

Note:
1. The Control Disabled alarm shall be comprised of:
   - ACTUATOR CONTROL SELECTOR NOT IN AUTO (REMOTE) OR MANUAL (LOCAL)
   - ACTUATOR LOCAL CONTROL LATCHABLE SWITCH ACTIVATED

If interposing relays are required to generate extra limit switch contacts, then these relays shall operate in a "failsafe" manner.

### E12.3.7 Position Transmitters

Actuators for modulating duty shall be fitted with 4-20mA position loop powered transmitters. For integral actuators, the power supply for which shall be derived from the actuator power supply.

### E12.3.8 Torque Switches

The actuator shall include an adjustable torque switch arrangement to break the control power circuit when there is an excessive torque. Torque switches shall open whenever an excessive torque condition occurs in its direction of travel, but shall not cause the motor to be locked out for travel in the opposite direction. The torque switches shall be pre-set in the factory to suit the application.

Each torque switch shall have voltage-free contacts rated at 0.5A, 24V DC.
The torque switches shall be made of brass. Plastic switches will not be acceptable unless prior acceptance has been given by SWC.

The torque switches shall be totally sealed and permanently wired to prevent ingress of moisture. There shall be no bare contacts that the technician can accidentally touch whilst adjusting the actuator.

**E12.3.9 Actuator Control**

The control requirement of the actuator is dependent on whether the actuator is controlled by SCADA or IICATS.

**12.3.9.1 SCADA Control**

Actuators under SCADA control shall have the following mode selection and control:

Mode selection of the actuator shall be done via SCADA, mode selector switch integral to the actuator shall be removed. Where it is not possible to physically remove the mode selector switch, its function shall be disabled and physical use of the selector mechanism shall display the message "disabled" on the actuator LCD or actuator mounted operator interface display whenever it is used.

The "LOCAL" open/close hand station buttons integral to the actuator shall be disabled when the actuator is in "REMOTE" mode and enabled when the actuator is in "LOCAL" mode. If this is not possible, they shall be removed and replaced with open/close pushbutton station external to the integral actuator. Where it is not possible to physically remove the "LOCAL" open/close hand station buttons, their function shall be disabled and physical use of the button mechanism shall display the message "disabled" on the actuator LCD or actuator mounted operator interface display whenever it is used.

"LOCAL (FIELD)" Control at valve/penstock.

"REMOTE (AUTO/MANUAL/OOS)" Control by remote signals from the PLC.

All new actuators supplied for SCADA Control at treatment plants shall have integral starters. If an actuator without an integral starter is required to replace an existing similar actuator, there will be a specific written instruction from Sydney Water to that effect.

**E12.3.9.1.1 Data Communication Interface**

For integral actuators under SCADA control, where data communication is specified in the Project Specific Specification, the data communication shall be Profibus and shall have the following features:

1. It shall be possible to set a bit within the actuator program or parameter set that determines whether it is "Maintained" or "Non-maintained";

2. It shall be possible to enable and disable the actuator mounted open/close/stop buttons via Profibus based on a remote enable bit which may be toggled at any time. If the bit is toggled during transit and the actuator is "Maintained", it shall continue transit until the limit is reached. If the actuator is "Non-maintained", it shall stop dead;

3. When Profibus comms is healthy, the ability to use the actuator mounted open/close/stop buttons shall be determined by the remote enable bit. When Profibus comms is failed, the actuator mounted open/close/stop buttons shall be enabled. If the comms fails during transit and the actuator is "Maintained", it shall continue transit until the limit is reached. If the actuator is "Non-maintained", it shall stop dead;

4. When Profibus PLC bit is healthy, the ability to use the actuator mounted open/close/stop buttons shall be determined by the remote enable bit. When Profibus PLC bit is failed, the actuator mounted open/close/stop buttons shall be enabled. If the PLC fails during transit and the actuator is "Maintained", it shall continue ran sit until the limit is reached. If the actuator is "Non-maintained", it shall stop dead;
5. It shall be possible to set a "Fail open" bit or a "Fail close" bit in the actuator such that on Profibus comms fail or on PLC fail, the actuator will automatically drive to the open limit or the close limit with configurable time delay;

6. It shall be possible to connect a hardwired voltage free contact as a process interlock directly to the actuator. When the circuit is open, the actuator shall be inhibited from operating. When the circuit is closed, the actuator shall operate normally. When the process interlock is activated, the operation of the actuator shall be consistent irrespective of:
   - The control mode (FIELD, OOS, AUTO, or MANUAL)
   - Actuator is in transit or not in transit
   - Communication failure

7. The actuator shall be capable of interfacing to a field hand station away from the location of the actuator assembly. The hand station facility may comprise a separated portion of the actuator head or a dedicated pushbutton and position indication unit. Where the actuator has an open/close function, indication of end to travel shall be provided with the pushbuttons. Where the actuator has a modulating or mid-position function, the percentage open shall be provided with the pushbuttons. The operation of the pushbuttons for opening and closing at the remote location, shall exactly mimic the operation of the controls on the actuator head. If one set of controls are available, the other will be. If one set is disabled, the other will be.

E12.3.9.1.2 Hardwired interface

The control facilities/interface signal required for SCADA control actuators are shown in the relevant drawing template for the different types of valves/penstocks as follows:

<table>
<thead>
<tr>
<th>Valve/Penstock Type</th>
<th>Integral starter</th>
<th>PLC Failsafe to open or closed position</th>
<th>Maintained Running on PLC failure</th>
<th>Drawing Template</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-position</td>
<td></td>
<td></td>
<td></td>
<td>TE150</td>
</tr>
<tr>
<td>2-position</td>
<td>✓</td>
<td></td>
<td></td>
<td>TE150F</td>
</tr>
<tr>
<td>2-position</td>
<td>✓</td>
<td></td>
<td></td>
<td>TE154, TE154LI (with line isolator)</td>
</tr>
<tr>
<td>2-position</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>TE154M</td>
</tr>
<tr>
<td>Modulating</td>
<td></td>
<td></td>
<td></td>
<td>TE150Z</td>
</tr>
<tr>
<td>Modulating</td>
<td>✓</td>
<td></td>
<td></td>
<td>TE150ZF</td>
</tr>
<tr>
<td>Modulating</td>
<td>✓</td>
<td></td>
<td></td>
<td>TE154Z</td>
</tr>
</tbody>
</table>

The actuator shall have all the control interface/signals such as limit switches, over-torque limit switches, fault signals etc. as indicated in the relevant drawing template.

All control signal, limit switches etc. shall be voltage free contacts rated at minimum 0.5A, 24VDC.

12.3.9.2 IICATS Control

Actuators under IICATS control shall have the following mode selection and control:
The “LOCAL/OFF/AUTO” control selector switch and the “LOCAL” hand station shall be included in the integral starter.

"LOCAL" Control at valve/penstock.
"AUTO" Control by remote signals from the RTU/PLC
"OFF" Actuator disengaged.

Vandal-proof and pad-lockable cover shall be provided for the Control Selector Switch and pushbutton stations in the integral actuator starter to prevent unauthorized operation.

In addition to the above control modes, the actuator shall be provided with built in MODBUS data communication required for IICATS control.

**E12.3.10 Positioning**

The actuator should be capable of precise positioning. It must be capable of being stopped within 0.3% of desired set point.

Continuous duty is required, this ensures that we can adjust the positioner to achieve the fine control required in many processes.

**E12.4 Actuator Motors**

**E12.4.1 General**

The motor shall be constructed to withstand mechanical stresses induced by sudden and repeated reversals of the actuator during positioning.

The motor and driven unit torque speed curves shall match to ensure smooth, positive starting.

The motor shall be capable of at least 20 starts per hour for part turn actuators, 50 starts per hour for multi-turn actuators and 600 starts per hour for actuators used for modulating duty. It shall be capable of 3 continuous opening and closing cycles.

The output of the motor offered shall be at least 15% in excess of the maximum power required under any specified operating conditions.

All motor bearings shall be self-lubricating ball and/or roller types of standard design, except where waterproofing requirements necessitate other designs.

The motor and actuator mechanism shall be capable of withstanding an instantaneous reversal of rotation at any point of the valve/penstock travel.

The motor shall form an integral part of the valve/penstock actuator and shall be manufactured in accordance with the relevant parts of AS1359.

The motor shall be 400V, three-phase (or 230V single for single actuators), 50Hz, single speed, horizontal or vertical and squirrel cage.

The motor shall have class F winding insulation. The power factor of the motor at full load shall be not less than 0.8.

An earthing stud shall be provided on the motor frame or inside the terminal box.

**E12.4.2 Terminal Connections**

The actuator motor and wiring shall be readily detachable from the actuator by means of either a multi-plug or terminals and without disturbing torque or limit switch settings. The power and control wires shall be connected to the actuator via plugs and sockets or terminals. The plug/terminals housing shall be suitable to be indexed to allow for various cable entry orientations.
**E12.4.3 Anti-condensation Heater**

The motor shall have an automatic PTC controlled self-regulating anti-condensation heater, which shall allow the motor and limit switches to withstand long periods of idleness without damage to the insulation.

**E12.4.4 Over Temperature Protection**

At least one temperature sensing device of the PTC semi-conductor type shall be embedded in each of the three phases of the motor winding. These devices shall be wired in series to stop the motor whenever they are operated.

The temperature sensing devices shall actuate a common tripping relay at a temperature of 155° for Class F insulation and shall have a characteristic in accordance with AS60947.8. The resistance of each device shall be 1000 ohms at the tripping temperature for the class of insulation used.

The motor may be fitted with thermal switches, in lieu of PTC semiconductor devices, to protect the windings from over temperature.

**E12.5 Valve/Penstock Control**

The control requirement of the valve/penstock is dependent on whether the valve/penstock is controlled by SCADA or IICATS.

**E12.5.1 For Valves/Penstocks under SCADA Control**

Actuators under SCADA control shall have the following mode selection at the SCADA screen:

- "FIELD" Control by pushbutton station at valve/penstock
- "OFF" No valve/penstock operation
- "AUTO" Control by SCADA outputs.

The control facilities/interface signal required for SCADA control valves/penstocks are shown in the relevant drawing template for the different types of valves/penstocks as follows:

**SCADA CONTROL VALVES/PENSTOCKS**

<table>
<thead>
<tr>
<th>Valve/Penstock Type</th>
<th>Integral starter</th>
<th>PLC Failsafe to open or closed position</th>
<th>Maintained Running on PLC failure</th>
<th>Drawing Template</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-position</td>
<td></td>
<td>✓</td>
<td></td>
<td>TE150</td>
</tr>
<tr>
<td>2-position</td>
<td></td>
<td>✓</td>
<td></td>
<td>TE150F</td>
</tr>
<tr>
<td>2-position</td>
<td>✓</td>
<td></td>
<td></td>
<td>TE154,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>TE154LI (with line isolator)</td>
</tr>
<tr>
<td>2-position</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>TE154M</td>
</tr>
<tr>
<td>Modulating</td>
<td></td>
<td></td>
<td></td>
<td>TE150Z</td>
</tr>
<tr>
<td>Modulating</td>
<td>✓</td>
<td></td>
<td></td>
<td>TE150ZF</td>
</tr>
<tr>
<td>Modulating</td>
<td>✓</td>
<td></td>
<td></td>
<td>TE154Z</td>
</tr>
</tbody>
</table>

The actuator shall have all the control interface/ signals such as limit switches, over-torque limit switches, fault signals etc. as indicated in the relevant drawing template.
All control signal, limit switches etc. shall be voltage free contacts rated at minimum 0.5A, 24VDC.

**For actuator with integral starter**

The mode selector switch and open/close buttons and functions on the integral starter shall be removed or disabled permanently. (i.e. the valve/penstock shall be permanently in Auto and disabled from being changed except remotely by the SCADA. Note: The open/close pushbutton station for “FIELD” control of the integral starter is a separate hand station from the valve/penstock actuator as shown in the relevant drawing template.

Where it is not possible to physically remove the selector and pushbutton mechanism, their function shall be disabled and physical use of the selector and pushbutton mechanism shall display the message “disabled” on the actuator LCD or actuator mounted operator interface display whenever it is used.

**E12.5.2 For Valves/Penstocks under IICATS Control**

Actuators under IICATS control shall have the following mode selection and control:

For actuator with integral starter

The “LOCAL/OFF/AUTO” control selector switch and the “LOCAL” handstation shall be included in the integral starter.

- "LOCAL" Control at valve/penstock.
- "AUTO" Control by remote signals from the RTU/PLC.
- "OFF" Actuator disengaged.

Vandal-proof and pad-lockable cover shall be provided for the Control Selector Switch and pushbutton stations in the integral actuator starter to prevent unauthorised operation.

There must be no reference to "Emergency Stop" on the actuator or red mushroom button with yellow background unless the wiring associated with such a button employs Cat 4 safety circuits as defined by AS4024.1

For actuator with non-integral starter

The “L1/L2/OFF/AUTO” control selector switch shall be located on the valve/penstock control panel.

- "L1" Control at valve/penstock.
- "L2" Control at valve/penstock control panel
- "OFF" Actuator disengaged.
- "AUTO" Control by remote signals from the RTU/PLC.

**For both integral and non-integral actuators**

Selection of any position shall enable operation in the selected mode and prevent operation in any other mode. When the control selector switch is in the “OFF” position, no other modes of control shall be available.

Local manual control at each valve/penstock shall be initiated by selection of "LOCAL" or "L1" at the selector switch and operation of "OPEN", "CLOSE" or "STOP" push buttons on the actuator.

Local manual control at each Valve/penstock Control Panel shall be initiated by selection of "L2" or at the selector switch and operation of "OPEN", "CLOSE" or "STOP" push buttons on Valve/Penstock Control Panel.

Automatic control mode shall be initiated by selection of "AUTO" at the control selector switch.

Valve/penstock opening and closing cycles shall be the same regardless of location of the control selector switch.
The control facilities/interface signal required for IICATS control valves are shown in the relevant Control Requirement Diagram for the different types of valve/penstocks as follows:

**IICATS CONTROL VALVES/ PENSTOCKS**

<table>
<thead>
<tr>
<th>Valve/penstock Type</th>
<th>Integral Starter</th>
<th>Control Requirement Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-position</td>
<td></td>
<td>SSD/70</td>
</tr>
<tr>
<td>2-position ✓</td>
<td></td>
<td>SSD/73</td>
</tr>
<tr>
<td>Modulating (Digital Positioning)</td>
<td></td>
<td>SSD/71</td>
</tr>
<tr>
<td>Modulating (Digital Positioning) ✓</td>
<td></td>
<td>SSD/74</td>
</tr>
<tr>
<td>Modulating (Analogue Positioning)</td>
<td></td>
<td>SSD/72</td>
</tr>
<tr>
<td>Modulating (Analogue Positioning) ✓</td>
<td></td>
<td>SSD/75</td>
</tr>
<tr>
<td>RTU I/O List for all electric actuated valve/penstock types</td>
<td>All valve/penstocks</td>
<td>SSD/67</td>
</tr>
</tbody>
</table>

The actuator shall have all the control interface/signals such as limit switches, over-torque limit switches, control indicator position contact, fault signals etc. for use by the integral starter or the Valve/penstock Control Panel as indicated in the relevant Control Requirement Diagram.

All control signal, limit switches etc. shall be voltage free contacts rated at minimum 0.5A, 24 V DC.
**E13 Pneumatic Valve Actuators**

Where pneumatic actuators are used for opening and closing valves the pneumatic cylinders construction shall have aluminium bodies, steel shafts and grade 316 stainless steel trim/fastenings and shall be suitable for operation from a compressed air system with a pressure range between 550 kPa and 1000 kPa. Pneumatic cylinders shall be of the double acting type with the direction of operation determined by a solenoid operated spool valve.
E14 Field Cables

E14.1 Field Wiring - General

All cables shall be multi-stranded. All cable and earthing conductors, cable trays, ducts and conduits shall comply with AS/NZS 2053, AS/NZS 3000 and AS/NZS 3008. They shall also comply with *Telecommunications Cabling Provider Rules* from ACMA for a control system connected into Telstra communications system.

All cables shall be easily accessible for replacement. All cables and/or conduits shall be grouped as far as possible and all supports, brackets, saddles and clips spaced to ensure that the runs remain straight and in any case shall not exceed 1 metre between centres.

Where new cables are to be run, the sheath colour shall match the colour or existing cables in adjacent installations.

Cables shall not be laid under areas designated for future switchboards.

In switchrooms with infinite access floors the power and control cabling shall be neatly arranged on cable trays underneath the infinite access floor.

In switch rooms and plant rooms with cable trenches, all cables shall be installed neatly inside the trenches with branched off cables wall mounted in cable trays or surface run conduits.

In the plant rooms without cable trenches, cable trays and surface run conduits shall be used for all cable routes whereby the main cable routes shall be wall mounted “overhead” and at least 2100mm above the finished floor level.

All wiring, junction boxes, terminal boxes and the like shall be arranged so that there is ample access for replacement, modification and maintenance.

All cable entries shall be machine-cut (hole saw) and free of burrs and sharp edges. Cutting of holes by burning methods shall not be acceptable.

Care shall be exercised when laying cables in ducts, cable ways, trenches and ladder trays. They shall be neatly layered and run parallel. Wherever possible cables shall be run in North-South or East-West straight runs. Bunching will not be acceptable and crossovers shall be confined to cables entering and leaving the medium.

All external cables shall be double insulated and run in an underground conduit and pit system.

All cables shall be terminated in compression type cable glands. PVC glands are acceptable provided that they are shrouded from sunlight and not subject to vandalism.

(NB: Brass glands shall not be used with aluminium or aluminium alloy boxes.)

Power cables shall be run on separate cable trays to control and instrumentation cables.

The control, instrumentation and communication cables shall be spaced a minimum 300mm apart from power cables.

Where power cables and instrument cables share the same cable tray, a barrier strip shall be installed to separate power cables from other cables. The barrier strip shall be of the same material as the cable tray and secured to it.

Cables run on ladder trays shall be fixed according to section 15.13. HV cables shall be fixed with stainless steel ties designed for HV cabling.

All cables installed above ground and external to buildings shall be installed in cable trays with the final connection to equipment in heavy duty flexible conduit.
All cables shall be continuous throughout their route length from the primary device i.e. limit switch, instrument, motor, to the control panel or SCA without the use of junction boxes. No 'through joints' or junction boxes will be permitted. An exception to this requirement shall apply to submersible pumps, where the cable shall be terminated with a plug/socket or terminal box to facilitate removal of the pump.

All cable cores shall be terminated in terminal strips whether within switchboards, panels, junction boxes or any other enclosure with insulated compression type lugs suitable for use with the size of the conductor, type of cable being used and the type of terminal strip employed, as follows:

Copper conductors shall be terminated either into tunnel type connectors or by suitably sized lugs, crimped in the correct manner. Where stud or pillar type terminals are used, the stranded conductors shall be prevented from spreading. Twisting stranded conductors is not considered adequate to prevent spreading.

1. For clip on rail terminals (clamp type) use crimp-on compression type pin connectors
2. For stud terminals use crimp-on compression type lugs
3. For tunnel type terminals use crimp-on compression type stalk lug or similar.

Where lugs are to be fitted, each wire shall have sufficient length to permit replacement of a lug. For all other cables adequate slack shall be provided at each end to allow for at least two (2) re-terminations and connections.

At all terminations of power cable cores, whether HV or LV, correct phase to phase relationship and phase rotation shall be maintained.

All spare cable cores shall be terminated on terminal strips, earthed (at one end only for instrument cables) and identified as spare 'SP'.

All terminations of mixed voltages shall be segregated from each other with extra-large voltage barriers and engraved plastic labels shall be affixed indicating the appropriate voltage e.g. 24V DC, 48V AC. Voltages above 32V AC and 100V DC shall be labelled with red lettering on white background engraved ‘DANGER’, together with the voltage.

Cables shall not be bent in a radius less than twelve (12) times their outside diameter.

The number of cables in ducts and the like shall be such that the space factor requirements of AS/NZS 3000 are complied with.

The number of cables in ducts, cable ways, trenches and the like shall be in conformity with the requirements of AS/NZS 3008 and its derating factors.

Cables on ladder trays shall not exceed three layers and shall be fixed, at a minimum of 600 mm intervals for horizontal trays and 300 mm intervals for vertical trays, according to section 15.13.

Cables in concrete trenches shall not exceed three layers.

Unless otherwise indicated, copper conductors shall be used throughout.

The minimum size of conductors shall be as follows:

- Power circuits 7/0.67 mm [2.5 mm²] copper
- Control circuits 7/0.50 mm [1.5 mm²] copper

Correct phase colours, orientation and rotation shall be maintained, at all terminations of cables throughout the installation.

Distributed field cabling shall follow the orientation of process pipe routing where possible.

Field cable distribution from the main cable routes shall be along the shortest route to the field termination and/or pull boxes.
Cable routes mounted along or across access ways shall not present a hazard to vehicular traffic, cranes or personnel using these access ways.

All decommissioned cables shall be removed and disposed from the existing pits, conduits and cable trays/trunkings and rearrange the existing / remaining cables in association with the new cables.

Any cable which suffers abrasion or damage to the insulation during drawing in shall be replaced.

E14.2 High Voltage Power Cables

The requirements of high voltage power cables and installation are covered in Clause 5 and the specifications listed therein.

E14.3 230/400 V Power Cables

Power cable shall be circular section orange PVC/PVC and shall have colour coded cores and earth conductor and be multistranded copper conductors and shall comply with AS/NZS 5000.1 or AS/NZS 5000.2.

Screened power cables shall be used for variable speed drives and have black or colourless (clear) sheath.

230V Multi-core Control Cables

Cables shall be multi-core orange sheathed circular section PVC/PVC, and shall be 0.6/1kV grade to AS/NZS 5000.1.

Cable cores shall be white and numbered with the number printed on each core. The numerals shall be printed at intervals of not more than 100mm.

E14.4 Extra Low Voltage Cables

All ELV cables shall be black or grey sheathed PVC/PVC. Where the cable is to be used for controls/instrumentation, the cable shall be PVC/screen/PVC.

Where the ELV cable is connected to a battery, the cable shall comply with AS4044.

E14.4.1 Single-Pair Cables (Instrumentation) for Field Wiring

Instrument (4-20mA) signal cable shall be twisted pair, with multi-strand copper conductors. Minimum size of conductors shall be 7/0.50mm (1.5mm2). The cores coloured white (positive) and black (negative).

E14.4.2 Multi-Pair Cables (Instrumentation) for Internal Wiring

Multi-pair instrumentation cables shall be used inside the switchboard or panel only.

Conductors shall be of copper, with minimum size of 7/0.30mm (0.5mm2). Each pair of conductors shall have black and white coloured cores. The white core of each pair shall have numbers printed on the insulation at intervals of not more than 100 mm.

E14.4.3 ELV power cables.

ELV power cables shall be multicore cables with integral earth. The white core of each pair shall have numbers printed on the insulation at intervals of not more than 100 mm.

E14.5 Intrinsic Cables

Cables used in hazardous area for intrinsic installation shall be blue sheathed from the barrier to the equipment in the hazardous area.

Cables entering hazardous area Zone 0 or Zone 1 shall be armoured.
E14.6 Cables for Exd Application
Cables connecting Exd equipment (eg motors) shall be steel wire armoured.

E14.7 Communication Cables
Communication cables for Modbus or similar application shall comply with the requirement in Sydney Water IICATS specification.

E14.8 Labelling and Identification
All power cable cores shall be identified at each termination by the appropriate red, white and blue phase colour, and black for the neutral.

All earth conductors shall be identified at each termination by the colour green or green yellow. Other colours will not be acceptable. Under no circumstances shall the colour green or green yellow be used for other than earth conductor identification.

All cable cores including neutrals and spares shall be identified at each termination using numbered full sleeve interlocking cable marker ferrules of correct size to fit the insulation of the cable core being terminated. The cable core identification shall be in accordance with the cable schedules and/or interconnection wiring diagrams.
E15 Electrical Installation

E15.1 Work on High Voltage Equipment or in High Voltage Area
Please refer to Clause 5 in relation to the requirements on installation work on high voltage equipment or in high voltage area.

E15.2 Materials and Workmanship
All materials are to be new and the best of their respective kinds. The workmanship throughout shall be first-class and carried out by competent tradesmen.

All stands and cabinet fixing components shall be supplied. All fixings shall be stainless steel.

All external materials shall be corrosion resistant and shall not be subject to UV degradation.

E15.3 Certificate of Compliance Electrical Work (CCEW)
Evidence of the electricity distributor’s approval of the complete electrical installation shall be obtained by the installer and submitted to Sydney Water before the electrical installation will be considered complete.

E15.4 Site Assembled Equipment
Where the installer is required to site assemble electrical equipment, he shall be responsible for all levelling and alignment. The installer shall also ensure that all components are correctly assembled and interconnected and that interface alignments are parallel and neat fitting.

E15.5 Materials Storage and Housekeeping
Installer shall be responsible for supply and delivery of all materials, appliances and fittings required for the work on site and shall be responsible for storing, cleaning, protecting against damage and preserving all material.

Any damage to, soiling, or theft of fittings, materials or accessories, shall be made good by the installer at his own expense.

Installer shall:
- Ensure that working and storage areas under his control are kept clean and tidy at all times.
- Ensure that waste material resulting from his work is regularly removed from site.
- Ensure that all switchboards, cable trenches, cable ducts and the like are kept free of debris, (for example cables, shavings, cable tie off-cuts and insulation off-cuts).

E15.6 Electric Welding - Construction Precautions
Installer shall ensure that no welding currents pass through any power or earthing conductor to any part of the structure, plant or electrical apparatus during the installation and particularly whilst the earth system is not complete.

During welding, all possible parallel or series conductor paths shall be isolated, if necessary, by disconnection, from the part being welded.

Instrument type low voltage cables shall be disconnected and isolated before welding commences in every instance.

E15.7 Redundant Items
All existing equipment and materials that become redundant as a result of the design and modifications to the plant or as a requirement of the works are referred to herein as redundant items.
Redundant electrical equipment and cabling include all redundant instruments, cables from switchboard to the field, cables from switchboards to other electrical panels inside and outside the switchroom, all wiring within panel and cabling between panels and any other redundant electrical items.

The installer shall:

- Ensure all redundant electrical equipment and cabling are electrically isolated, disconnected, removed from the site in a safe manner and the site made safe in accordance with appropriate statutory requirement.
- All redundant items are disposed in an environmentally safe manner and in accordance with the appropriate statutory requirements.
- Provide disposal certificates as a part of the project documentation.

Subject to written Sydney Water acceptance (the Plant Manager AND an appropriate Sydney Water electrical representative), a redundant item may be left in-situ where:

- The removal may result in damage to other items (i.e. cables) that are remaining in service; or
- Are impractical to remove.

The Redundant equipment to be left in situ shall be assessed and accepted on a per item basis (e.g. One cable or one piece of equipment).

The following must be performed as a minimum:

- A laser etched stainless steel label with the word “redundant” and the original asset number attached (cables must have labels at both ends). The label must be affixed with stainless steel ties or permanently affixed.
- Conductors must be shorted together and bonded to a protective earth.
- For cables, both ends of the cable cut off at agreed points, all cores shorted together and ends heat shrink capped. Where cable ends may be subjected to poor environmental conditions (e.g. outdoors or contamination), the cable ends must be provided with additional protection.
- A Sydney Water “Redundant equipment” tag attached at both ends.
- Equipment made redundant shall be reflected in the relevant drawings.

**E15.8 Mechanical Protection**

Mechanical protection shall be provided on all electrical and instrument equipment under the following conditions:

- When mounted within 1.5m above a floor or access platform.
- When subject to damage during normal plant operation and maintenance.
- On which scaffolding and/or planks may be placed, or which may be used as a means of access for abnormal plant maintenance.

Cables requiring mechanical protection shall be installed in galvanised steel water pipe. Conduits requiring mechanical protection shall be galvanised steel water pipe.

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 including the possible use as an access by maintenance personnel. Covers, when used outdoors, shall be constructed of minimum 2mm hot dipped galvanised steel material or aluminium when fitted to cable trays and be painted as required in the specifications.

Sheet metal covers installed to provide mechanical protection of electrical equipment shall be constructed so as to totally enclose such electrical equipment and associated conduits and/or cables.
Any device for the mechanical protection of conduits and/or cables shall be free of burrs and sharp edges. Additional bushing, sleeving or other means shall be provided as required to prevent conduit and cable damage.

E15.9 Sealing

Installation work shall:

- Vermin proof and effectively seal all openings, ducts, trenches, cable ways or the like made for the entry of electrical conduits and cables through external walls of buildings, with a weatherproof concrete grout and for those through internal walls of buildings, with a weak mix concrete. Silicon rubber and EPS foam will not be acceptable.
- Ensure that all spare conduits and ducts are effectively plugged and sealed.
- Ensure that all openings are made weatherproof, by the installation if necessary of flashing and/or rain hoods to prevent, for example, the entry of water, driving rain and/or water seepage.
- Ensure that all cable entry to cubicles and panels be sealed and as detailed elsewhere in the specification.
- Fire rated seals shall be used for switchrooms.

E15.10 Supporting, Mounting and Positioning

All electrical equipment shall be located, arranged, mounted and positioned so that it is readily accessible for operation, inspection, replacement, modification and maintenance without the use of scaffolding and/or machineries like cranes, cherry pickers etc. To enable removal of equipment weighing more than 20 kg, provision shall be made to enable lifting of equipment with the use of a lifting device. Consideration shall be given for heavy equipment like VSD to be mounted on a trolley so that these can be racked out of the switchboard to gain access to lift out heavy components like reactors. If infinite access floors are installed these need to be considered as well in removing heavy electrical equipment mounted on trolleys.

Cables trenches, trays, ladders, pits and fitting system shall not be shared with any other services.

All independently mounted equipment shall be mounted onto fixed structures. Where no fixed structure is available the installer shall supply and install a structure for the mounting of such equipment.

All switchboards and starters installed in switchrooms shall be floor mounted. All switchboards installed in switchrooms with infinite access floors shall be mounted on a dedicated fixed galvanised steel frame that sits on the concrete floor. The switchboard plinth shall be in level with the infinite access floor.

All mounting supports, brackets, plates and similar pieces of apparatus shall have space allowance for equipment identification.

All electrical equipment shall be labelled. Labels exposed to the weather shall be engraved stainless steel infilled with black paint.

All mounting supports, brackets and plates shall be free from burrs and sharp edges. They shall have all holes drilled or machined and shall be painted as required by this Specification.

Cutting of holes by burning methods shall not be acceptable.

All mounting supports, brackets, plates and the like used for the mounting of electrical equipment shall be so constructed to prevent vibration due to wind, operation of adjacent equipment or other dynamic forces.

All screws and bolts used for the mounting and fixing of electrical equipment shall be of the correct size and length.

Explosive or impact power tools shall not be used for placing mounting studs and the like.

All electrical equipment mounted along or in access ways shall be positioned so that it does not present a hazard to vehicular traffic or personnel using the access way.
All cables, cable trays, cable ducts, conduits, fixings and supports etc., shall be installed in locations that do not interfere with the normal operation and maintenance of the plant.

All necessary packets, shims and grounding shall be fitted to ensure correct levelling and alignment of equipment installed. Shims, packers, etc., shall be hot dipped galvanised.

Fibre or nylon washers and mounting pads shall be interposed between bolts and equipment of dissimilar materials to prevent electrolytic corrosion.

Where three or more conduit or cable runs are grouped together, they shall be mounted on suitable sized cable trays and ladders. Single or double runs may be fixed direct to walls, structural members and the like. Holes must not be drilled through the flanges of RSJs or channels.

Conduits and cables shall be supported by saddles or cleats so that there is not weight taken by the conduit termination or cable gland and such that no force is exerted on core terminations.

Saddles shall be double sided stainless steel, fixed with stainless steel screws. Single sided saddles shall not be acceptable.

Special care shall be taken when saddling single core cables or conduits containing single core cables. Ferrous saddles shall not be used when fixing such cables or conduits to metal structures. In particular, care shall be taken with single core cables or conduits containing single core cables when run on cable trays or conduit racks, to ensure that steel support brackets do not form a magnetic path around such cables or conduits.

Cleats, wooden or otherwise, used for clamping conduits and cables shall firmly clamp, without distortion or damage, such conduits and cables.

Saddles, junction boxes and the like shall be fastened using plastic plugs for up to No. 8 size stainless steel screws, for larger fastenings, stainless steel Dyna bolts or Loxin anchors or chemical anchors shall be used.

Sufficient length of waterproof flexible conduit and/or cable shall be provided, where applicable, to permit the following:

- Positional adjustment of electrical equipment without electrical disconnection, for example, limit switches and the like.
- Removal and/or positional adjustment of driven equipment without electrical disconnection of the motor.
- Full motor travel adjustment without straining or chaffing conduits and/or cables, or electrical disconnection of motor.

Flexible conduits shall be of the plastic sheath, smooth, PVC spiral reinforced type and shall be oil resistant, UV resistant and impact resistant. The fittings shall be compatible with the chemical in the area and offer IP67 degree of protection.

E15.11 Bolts, Nuts, Washers and Joining Materials

Bolts, nuts, washers and other demountable fastening located outdoors for all dissimilar metals shall be in stainless steel grade 316 to remain unpainted. Fibre or nylon washers and mounting pads shall be fitted between metal washers and materials being fixed or joined.

All bolts and nuts shall have metric threads to the Australian Standards.

E15.12 Terminal Boxes

E15.12.1 Control Cabinet Terminal Boxes

All control cabinets shall have a minimum of IP52 rating. Material shall be either 2.0mm (minimum) hot-dipped galvanised sheet steel or 1.5mm (minimum) 316 grade stainless steel.
The control cabinets shall be provided with side hinged door with a minimum of 120 degree opening for access, the door shall be provided with a suitable operating handle equipped with locking facility based on the application.

All doors and removable panels shall have a continuous closed cell polyethylene (or better) gasket or solid neoprene coated sponge rubber gasket fitted around the edges to seal them in accordance with the specified IP classification.

Control cabinet enclosures and doors shall be bonded to earth to create equipotential.

Stress free instrument panels shall be provided such that no distortion will occur when instrument cut outs are made. Cut outs shall be smooth and accurate to 1mm. Burrs and sharp edges shall be removed. Instrument and electrical equipment mounted through panels shall be sealed to confirm to the specified IP classification.

The control cabinet shall typically house the following:

1. Operation counter for CB or switch
2. LOCAL-REMOTE control selector switch
3. OPEN-CLOSE control switch with appropriate indication lights
4. Electricity metering unit
5. Local close relays, anti-pumping relays and other required auxiliary circuit equipment
6. Any control for valves, indication, and pressure gauges as required
7. Terminals pre-wired with the circuit breaker auxiliary contacts
8. Telemetry equipment
9. Lights and GPO
10. Other terminals and control wiring

Low voltage circuits must be segregated from extra low voltage circuits as per AS3000. A person working on an extra low voltage circuit shall not be at risk of touching a low or high voltage circuit.

Cables and wiring shall not share common ducts.

Any deviation must be highlighted to SWC.

### E15.12.2 Junction Boxes

All junction boxes shall have a minimum of IP55 rating. They shall be constructed from a high-strength and UV resistant plastic such as PVC UVR. Where the junction box is to be exposed to UV radiation, the enclosure shall be coated in a grey-scale acrylic paint for further UV protection. Cable entries shall use cable glands and provide waterproof entry, with a sealing plug to be used for spare entries.

### E15.13 Cable Ladder Trays

Cable ladder trays shall be supported on galvanised steel brackets with a designed load of 75 kg per square metre. Cable ladder trays shall have supports at joints and intermediate supports at not more than 2 m centres. Brackets shall be spaced so that the loaded cable tray and ladder deflection does not exceed 5mm.

Cable ladder trays shall be constructed from an appropriate material based on the intended installation conditions. The cable trays shall be installed as per manufacturer recommendations.

Galvanised steel shall be used for indoor and general outdoor environments. Marine grade aluminium shall be used for sites within two kilometres of the coast or where a higher level of corrosion resistance is required. Stainless steel or non-conductive material may be accepted. The material selection must be confirmed with, or specified by SWC. Lifecycle cost and corrosion resistance to conditions such as salt air, gases and chemicals shall be considered.
All supports, fittings, brackets, bolts, nuts and washers shall match the cable tray and ladder type employed. Where the cable ladder trays surfaces have been cut or damaged during installation they shall be repaired by removing rough edges and coating as per WSA 201 and Sydney Water’s Supplement or Sydney Water’s FRP specification.

Galvanised steel cable ladder trays shall be hot dipped galvanised after manufacture. 2.0 mm steel. All supports, fittings, brackets, bolts, nuts and washers shall also be hot dipped galvanised. Cut or damage to the exposed metal shall be coated immediately with a two part zinc rich epoxy paint, as per WSA 201 and Sydney Water’s Supplement, to prevent corrosion.

Aluminium cable ladder trays shall be heavy duty marine grade aluminium with continuous ventilated base.

FRP cable ladder trays shall be supplied with the fixings as recommended by the manufacturer. Detailed requirements for the reinforcement fibres, resin properties, gel coats and surface veils shall be confirmed with SWC. All cut ends, holes and abrasions shall be sealed with resin in accordance with the manufacturer’s instruction.

Where used stainless steel shall be grade 316. Cuts or damage shall be repaired using pickling and passivation as per WSA 201 and Sydney Water’s Supplement to restore the protective oxide layer.

Where practical all metal cable ladder tray system components shall be made of the same material and have the same finish. If interfaces of dissimilar metals occur they shall be insulated or fully and effectively coated to prevent galvanic corrosion as per Part 2 Mechanical Works of this specification.

For cable trays and ladders installed in areas subject to sunlight, water ingress, rain or contamination by foreign material, non-ventilated peaked covers must be installed. For layered installations, covers are required on the upper most/ most exposed layer only.

All cable tray and ladder covers shall be fixed by clamps, fixed every 600mm, consisting of channels across the lid surface held by "J" bolts and nuts or as specified by the manufacturer.

Cables should be fastened to the cable ladder tray using cable cleats or cable ties to prevent movement or damage of the cables, cable tray or cable ladder, under normal use and during fault conditions. Cable cleats and cable ties should be correctly sized and only tightened enough to secure the cable without damaging the insulation sheath. Where possible cable cleats should be positioned on alternate rungs of the cable ladder to evenly spread the load along the length.

All cable trays and ladders shall be equipotential bonded for protective earthing purposes as per AS3000. Tray systems shall be mechanically and electrically continuous using tees, bends, ramps and fly-overs.
E16 Works Tests and Inspection

E16.1 Factory Acceptance Testing - High Voltage Equipment
High voltage equipment shall be subjected to factory tests as specified in the equipment specification listed in Clause 5.

E16.2 Factory Acceptance Testing - Low Voltage Equipment
The switchgear shall be tested in accordance with the requirements of the appropriate Australian Standards and as required by authorities having jurisdiction, such as the electricity distributor.

As a minimum, tests shall include:

1. Insulation resistance.
2. Power frequency voltage withstand.
3. Resistance of primary circuits and earthing circuits, including busbars, switching devices and earthing switches.
4. Verification of correct wiring.
5. Mechanical operation of all switch devices and interlocks.
6. Verification of instrument and control transformer ratios, polarities and connections.
7. Magnetising curves of current transformers.
9. Functional tests of control and protection circuits, including tests at the stated limits of control and auxiliary supply voltages.
10. Accuracy check of meters and transducers, at 25%, 50%, 75% and 100% of full scale, minimum.
11. Performance checks of protection relays at a minimum of four points on the operating curve, including pick-up.
12. Verification of correct functioning of all ancillary devices and equipment such as slow-close levers, manual spring charging devices, test leads, earthing equipment, wear gauges.
13. Ductor test on busbars.

Primary injection shall be used to verify the correct polarity and ratio of each protection current transformer and the operation of the associated protective relay(s) for at least one current. Testing for verifying the protective relays’ calibrations at other currents shall be secondary injection testing.

Primary injection tests shall be performed on each metering current transformer and its associated meter(s) or transducer(s). As a minimum, these tests shall be performed at one half and at full scale values.

If, due to limitations of test equipment, a phase-controlled 3-phase current test source is not readily available, 3-phase meters and transducers may be tested using single-phase current sources.

Where practical, FAT shall be made available for Sydney Water representative to attend.

E16.3 Site Test
Site test shall be performed and recorded on test sheets to ensure equipment integrity and correct site wiring.

As a minimum, tests shall include:

1. Insulation resistance.
2. Power frequency voltage withstand.

3. Resistance of primary circuits and earthing circuits, including busbars, switching devices and earthing switches.

4. Verification of correct wiring.

5. Mechanical operation of all switch devices and interlocks.

6. Verification of instrument and control transformer ratios, polarities and connections (if this has not been done in factory acceptance test)

7. Functional tests of control and protection circuits, including tests at the stated limits of control and auxiliary supply voltages.

8. Accuracy check of meters and transducers, at 25%, 50%, 75% and 100% of full scale, minimum (if this has not been done in factory acceptance test).

9. Performance checks of protection relays at a minimum of four points on the operating curve, including pick-up.

10. Verification of correct functioning of all ancillary devices and equipment such as slow-close levers, manual spring charging devices, test leads, earthing equipment, wear gauges.

11. Injection test for protection relays.

**E16.4 Testing and Measuring Instrument**

All testing and measurements shall be carried out using NATA certified instruments. These instruments shall be capable of printing out the readings and the results shall be submitted as instrument printouts and not as read out.
**E17 Documentation**

All documentation listed in this Section must be submitted as two (2) hardcopies and one (1) electronic copy on a USB flash drive.

**E17.1 Design calculations**

Design calculations must be reviewed and verified by a suitably competent person as stipulated in the Sydney Water engineering competency standard. The following calculations must be provided as a minimum:

1. Cable sizing
2. Transformer sizing
3. Generator sizing
4. Battery sizing
5. Short circuit current calculation up to 415V distribution/protection circuit breakers
6. Power factor correction equipment sizing
7. Harmonic filtration equipment sizing
8. HVAC calculations and design for rooms containing electrical equipment
9. ELV supply sizing
10. ELV cable sizing
11. Lighting calculations

**E17.2 System study reports**

System study reports must be provided for acceptance as part of the project handover. The final report must include following three parts:

1. The initial assessment study for the new design and existing system impacted by the new design with proposed engineering mitigation methods for any issues flagged in the initial assessment, this part must be finalised and reviewed at the concept design to acquire the baseline of the system and provide input for detail design.
2. A proposed detailed design addressing the items identified in the initial assessment study. This must consist of engineering designs and calculations based on the agreed method from the initial assessment study. This part must be finalised and reviewed at the detail design.
3. The final results showing the design and modifications meets the technical requirements, this part must be finalised during the commissioning of the installations.

The requirements for system study reports applies to following subjects:

1. Power quality (harmonic, power factor, flicker)
2. Earthing System
3. Lightning System
4. Surge protection
5. Arc Flash Assessment
6. Protection System Co-ordination
7. Load Flow Analysis (including load distribution and maximum demand)

**E17.3 System modelling**

The system model and associated library files must be submitted on two (2) copies on USB flash drives.
E17.4 O&M Manuals
The equipment manuals shall be submitted on hard copies and USB flash drives containing sufficient information for the operation, maintenance and fault finding. Supplier details and technical support contacts shall be included. Two sets of hard copies and USB flash drives shall be submitted.

E17.5 Work-as-constructed (WAC) Drawings
Work-as-constructed drawings shall be submitted on A3 hard copies and USB flash drives with an index of all drawings. Two sets of A3 hard copies and USB flash drives shall be submitted. The drawing files shall be in both AutoCAD and PDF format.

The following drawings as a minimum, must be submitted as a part of the Work as Constructed drawings:

1. Electrical services block diagram
2. Electrical services site layout
3. Conduit site layout
4. Cable routes and installation diagrams showing location and dimensions of conduits, pits, cable trays, cables, sizes and spare/future capacity installed
5. Switchroom layout
6. Single Line Diagrams including protection details of the installation
7. Cable schedules, interconnection and termination diagrams. The diagrams must identify every cable and core including sizes and spare capacity.
8. IICATS/SCADA equipment, connection, I/O and controls interface diagrams
9. SCA plinth and conduit layout
10. Fully dimensioned general arrangement and construction drawings of starters, control panels, MCC/SCA showing the location of all components (including the terminals for external wiring), bus bar support arrangements, compartment detail including mounting panel detail and equipment door layouts and forms of segregation.
11. Fully dimensioned panel sheet metal and construction drawings incorporating structural and assembly details, door locking arrangements, surface treatment and painting instructions.
12. Equipment schedules including model numbers
13. Label schedule with details
14. Single line UPS diagram with protection details (when installed)
15. Starter circuit diagram for all motor starters
16. Control circuit diagrams including PLC and RTU I/O
17. Emergency operation circuit diagrams
18. ELV DC single line diagrams (when installed)
19. Earthing arrangement diagrams, including general arrangements, cables, connections and test points. The GPS co-ordinates for the earth stakes and test points must be recording on the general arrangements.
20. Lighting drawings
22. Instrument loop diagrams
23. Underground power cable layout diagram including cable sizes, cable lengths, cable numbers cable elevations, pit sizes and GPS co-ordinates, pit layout and cable joints

IICATS and SCADA drawing requirements are detailed in the Instrumentation and Control Standards TOG TS01 and the Treatment and Plant SCADA Standards.
E17.6 Devices requiring configuration through proprietary hardware and software

For any devices that require configuration, the configuration file and parameters must be provided. The native configuration file, required software, licenses and, any specific hardware (i.e. license dongles, interface cables) to configure the device must be supplied.

Prior to purchase any proprietary equipment, SWC must be consulted to what proprietary equipment is required.

E17.7 Test Reports

All test reports during factory testing, site testing, commissioning testing shall be submitted on USB flash drives. Two sets of USB flash drives shall be submitted.