Technical Specification - Electrical

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Revision details

Version No.	Clause	Description of revision
1	All	New revision Publish Date : 21-May-08
2		Updates on : Electrical actuator spec, flammable gas hazardous area guidelines, other minor changes Publish Date : 31-Mar-10
3	E9.9, E2.9, E 9.22.3, E5.1 and E9.22.3	Updates on : [E9.9] Protective coating standard revised. (E2.9, E9.22.3) Harmonics requirement changed (E5.1) Transformer MEPS added. (E9.22.3) RCDs for VSDs added. Publish Date : 05-Apr-11
4	E4.1, E5.1, E14.6 and E14.9	Updates on : E4.1 Pits and Conduits - Paragraph 4 Added E5.1 Specification PCS 100 replaced PCS 104 and 106. E14.6 Materials Storage - Title changed & Clause added E14.9 Redundant Items - new clause added Publish Date : 17-Oct-12
5		Updates on : 1. Organisational/legislative changes 2. Design considerations 3. Drive isolators and interlock 4. Harmonics study requirements 5. General lighting, power 6. Installation of conduits/cables 7. Starters/control cubicles 8. High Voltage requirements Publish Date : 01-Oct-13
6	E1.1, E2.8, E2.10.3, E6.6, E6.6.1, E6.8, E7.3, E8.1, E9.4.1, E9.17, E9.25, E11.4, E2.10.2, E5.1, E9.9, E9.3, E9.22.1, E4.3, E6.1 and E9.23	Updates on : Comply with Treatment Plant SCADA Standard, templates and Profibus communications protocol - E1.1 Scope, E2.8, E2.10.3, E6.6, E6.6.1, E6.8, E7.3, E8.1, E9.4.1, E9.17, E9.25, E11.4 Handstations to be determined by risk assessment - E2.10.2 Replaces PSC100 by WSA 021 and Sydney Water Supplement Outdoor installation of VSD - E9.3, E9.22.1 E4.3 – delete last dot point of 7th paragraph E6.1 – delete 4th paragraph E9.23 – 24V control to be used unless specified otherwise Publish Date : 13-Jan-14

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7	E1.1, E2.8, E2.9, E2.10.1, E4.1.1, E4.1.4, E4.1.6, E4.3, E4.5, E6.6.3, E9.2, E9.5, E9.8, E9.22.3 and E11.6	Updates on : Cover page – Infrastructure Delivery changed to Liveable City Solutions E1.1 – Clarifies IICATS requirements and includes the lifecycle cost for HV Equipment's E2.8 – Divided into sub headings E2.9, E2.10.1, E4.1.1, E4.1.4, E4.1.6 Minor correction E4.3 – Regrouped with sub headings E4.5 – Nominated security company removed. E6.6.3 – Duplicate battery backup requirement removed E9.2 – Panel door strength improved E9.5 – The SCA panel earthing of each unit specified E9.8 – aluminium gland plates increased thickness to 5mm. E.9.22.3 – RCD for all fixed installations E11.6 – Bearing temperature device must be IICATS compliant. Publish Date : 26-Jun-15

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8	E1.1, E2.3, E2.5, E2.7, E2.10.1, E2.10.2, E2.10.3, E3.1, E3.3, E4.3.1, E4.3.2, E4.8, E5, E6, E7, E8, E9.1, E9.4.2, E9.7, E9.8, E9.9, E9.10, E9.22.3, E10.1, E13.2, E14.1, E15.1, E16.4	Updates on : E1.1 HV related specification comments added E2.3 Generator connection panel information added E2.5 Hazardous area related documentations format added and IICATS signals for networks assets reference included E2.7 SKM power tools for power design added E2.10.1 Multilocking device for padlocks. E2.10.2 Latched stop removed E2.10.3 Additional interlocks added E3.1 Switchroom fire rating added to comply with BCA requirements, Fire extinguishers requirement updated E3.3 HV Requirements changed to reflect the HV tech specification E4.3.1 Upgraded included E4.3.2 Emergency exit sign location defined E4.8 Earth resistance test for earthing system E5 Modified to reflect HV specification E6 Removed E7 Removed E8 Removed E9.1 Safety protection shield included E9.4.2 IICATS communication requirements added E9.7 Location number added to the name plates E9.8 Multilocking device for padlocks E9.9 New outdoor kiosk colour added E9.10 Multilocking device for padlocks E9.22.3 EMC filter requirements improved, harmonic measurement location defined. E10.1 Clause added to reflect the HV spec E13.2 HV power cable removed to reflect the HV spec E14.1 HV installations removed to reflect the HV spec E15.1 HV test removed to reflect HV spec E16.4 HV Documentation modified to reflect the HV spec Publish Date: 23-Dec-15

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9	E1.2, E2.7, E2.9, E3, E4.7, E5, E9, E9.2, E9.6, E9.12, E9.18, E9.24, E10.7 and E12	Updates on : E 1.2 Clarify definition for LV, ELV E 2.7 Clarify requirement for electrical system studies E2.9 Mandate requirement for harmonics study E 3 Rewritten switchroom specification and remove HV switchroom section E 4.7 Specify earth bonding and testing requirements E 5 Remove duplication in HV section against HV spec E 9 Change reference across whole section to new AS standard E9.2 The Door handle requirement specified E9.6 Clause added to alternate control circuit phase E9.12 Clause added for phase failure to monitor all phases of the circuit. E 9.18 Amendment to Auxiliary Relay requirements E 9.24 Rewritten Auxiliary Distribution Board section E 10.7 Rewritten Isolation of power factor correction unit section E 12 Modification to Electrical Actuators Publish Date : 30-May-17
10	E2.5, E2.6, E2.11, E2.12, E3, E3.1.1, E3.1.3, E4.1.1, E4.7, E4.8, E9.2, E9.3, E9.4.3, E9.5, E9.9, E11.6, E13.1, E13.5, E14.9, E14.14, E14.5 and E16.4	Updates on : E2.5 Hazardous Area requirements updated E2.6 Power Factor Correction requirement clarified E2.11 Instrument transformers for revenue metering added E2.12 Heights requirement added E3. Electrical Switchroom updated E3.1.1 Fire Resistance requirement updated E3.1.3 Air Conditioning unit updated E4.1.1 Pits and Conduits updated E4.7 Earthing updated E4.8 Equipotential Bonding added E9.2 Indoor SCA updated E9.3 Outdoor SCA updated E9.4.3 Isolators updated E9.5 SCA construction updated E9.9 Surface Treatment and Painting Instructions updated E11.6 Temperature Protection updated E13.1 Field Wiring – General updated E13.5 Extra Low Voltage Cables updated E14.9 Redundant Items updated E14.14 Control Cabinet updated E14.5 Cable Ladder Trays updated E16.4 High Voltage Documentation deleted Publish Date : 25-Jun-18

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11	E1.3, E2.3, E2.7, E2.8, E3.1.4, E4.3.1, E4.5, E4.7, E4.8, E5, E9.1, E9.1.1, E9.2, E9.3, E9.10, E9.13, E9.20.1, E9.22.3, E9.24, E10.1, E11.2, E11.3, E11.5, E13, E15, E15.7, E15.13, and E17	Updates on : E1.3 Added ASP requirement E2.3 Added detail for standby generator E2.7 Amended power system related design and modelling content E2.8 New section for Arc Flash E3.1.4 Updated to comply with AS 3000 E4.3.1 Updated lighting requirements E4.5 Fire protection system requirements updated E4.7 The section is updated and re-written E4.8 Lightning protection is updated E5 Removed duplication with HV spec E9.1 Update to incorporate Arc Flash requirements E9.1.1 Added section for SCA switching operation E9.2 Update to comply with AS61439 E9.3 Updated outdoor SCA requirements E9.10 Updated Circuit Breaker protection requirements E9.13 Updated panel meter requirements E9.20.1 New section for Fault Limiting Fuse E9.22.3 Updated harmonic filter requirements and RCDs for VSD requirements E9.24 Updated Aux DB requirements E10.1 Updated PFC requirements E11.2 Added Motor sizing requirements E11.3 Updated to be consistent with Mech Spec E11.5 Added Bearing section E13 Migrate Pneumatic Valve Actuator section from Mech Spec E15 Removed Fees, Permits, Remedial Work and Making Good Sections E15.7 Updated Redundant equipment sections E15.13 Updated cable tray requirements E17. Re-written the documentation section Publish Date : 13-Aug-19
12	E2.17, E3.1.2, E9.2 , E12.2.1 ,E 17 and the whole document	Updates on : Changing ‘shall’, ‘should’ and ‘may’ to ‘must’ where relevant to SWC. ‘Sydney Water Corporation’ replaced with ‘SWC’. ‘Approved’ replaced with ‘accepted’. Minor editorial changes elsewhere. E2.17 Added Solar PV requirements E3.1.2 Updated access door requirements E9.2 Updated switchboard Internal Arcing Fault testing requirements E12.2.1 Updated blind plate padlock requirements E17 Remove the requirements of using USB drives for electronic copy submission

Foreword

This Specification is for the design, supply and installation of electrical works for Sydney Water Corporation (SWC) assets.

SWC makes no warranties, express or implied, that compliance with the contents of this Specification must 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 SWC.

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Acronyms

Term	Definition
AC	Alternating current
ACMA	Australian Communications and Media Authority
AS/ NZS	Australian Standard/ New Zealand Standard
ASP	Accredited service provider
CCEW	Certificate of compliance electrical work
CPEng	Chartered Professional Engineer
CRCQ	Cold rolled, commercial quality
CT	Current transformer
DC	Direct current
DIN	Deutsche Industrie Norm (German industrial standard)
DOL	Direct-on-line
DTC	Deemed to Comply
ELV	Extra-low voltage: Not exceeding 50 V AC or 120 V ripple-free DC
EMC	Electromagnetic compatibility
EPS	Expanded polystyrene
FAT	Factory acceptance test
FRL	Fire resistance level
FRP	Fiberglass reinforced plastic
GA	General arrangement
GPO	General power socket outlet

Term	Definition
GPS	Global positioning system
GRP	Glass-reinforced plastic
HDG	Hot dipped galvanised
HRC	High rupturing capacity
HV	Exceed low voltage
HVAC	Heating, ventilation, and air conditioning
I&C	Instrumentation and control
IDMT	Inverse definite minimum time (protection)
IEC	International Electrotechnical Commission (Standard)
IEEE	Institute of Electrical and Electronics Engineers
IICATS	Integrated Instrumentation, Control, Automation and Telemetry System
IICATS	Integrated instrumentation, control, automation and telemetry system
LD, HD	Light duty, heavy duty (conduits)
LED	Light emitting diode
LOTO	Lock out - tag out
LV	Exceed Extra-low voltage, but not exceeding 1000 V AC. or 1500 V DC
MOA	Manual Off Auto
MCC	Motor control centre
MEN	Multiple Earthed Neutral
MH	Man-hole
MOA	Manual-Off-Auto
N/O, N/C	Normally open, normally closed (contacts)
NATA	National Association of Testing Authorities
NCC	National Construction Code
NER	National Engineering Register
NFPA	National Fire Protection Association
PCB	Polychlorinated biphenyls
PCC	Point of common coupling
PE	Polyethylene
PFC	Power Factor Correction
PIV	Peak inverse voltage
PLC	Programmable Logic Controller
PTC	Positive temperature coefficient (thermistors)
PVC	Polyvinyl chloride
RCD	Residual-current device
RFI	Radio Frequency Interference

Term	Definition
RMS	Root mean square
RMU	Ring main unit
RPM	Revolutions per minute
RSJ	Rolled Steel Joist
RTD	Resistance temperature detector / device
SCA	Switchgear and control gear assembly
SCADA	Supervisory control and data acquisition
SCR	Silicon-controlled rectifier
SLD	Single Line Diagram
SPS	Sewage pumping station
SS	Stainless steel
STP	Sewage treatment plant
THD	Total harmonic distortion
UPS	Uninterruptible power supply
UPVC	Unplasticized polyvinyl chloride
UV	Ultraviolet
UVR	Ultraviolet resistant
VAR	Volt-amperes reactive
VSD	Variable speed drive
VT	Voltage transformer
WAC	Work-as-constructed
WFP	Water filtration plant
WPS	Water pumping station

General terms and definitions

Term	Definition
Competent Engineer	Suitably qualified and experienced engineer with the ability to apply knowledge and skills to achieve the intended design, construction, testing or monitoring task. For engineering tasks related to design, engineering personnel who meet requirements of the SWC Engineering Competency Standard.
Sydney Water	The nominated person or organisation that has written authority to act on Sydney Water's behalf.
Supplier	The person or organisation responsible for the fabrication or manufacture and supply of products, materials, equipment and components described herein.
WSAA Codes	Code of Practice issued by Water Services Association of Australia
WSAA Code - Sydney Water Edition	WSAA Code with modifications by SWC for use in SWC assets, when available.

E1 General

- 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 SWC 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 SWC'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 must 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 must 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 must consider the applicability of alternative designs.

The requirements are intended to provide a guideline to build electrical infrastructure to fulfil SWC'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 must 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.

E1.2 Compliance with authorities and standards

All work performed, equipment supplied, and modifications carried out to the existing equipment must 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 must 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 must be designed and installed in accordance with AS 2067.

All work must be of the best quality incorporating the best means of providing and installing all equipment including cables. All work must 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 must comprise a test certificate from an independent testing authority.

All design work must 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 must 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 SWC 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 must be designed to minimise electrical energy consumption. This must include but not be limited to the following measures, which must 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 e.g. VSD
- Use of filters to reduce harmonics (refer E2.9 and E9.22.3).

E2.2 Reliability and operation of process equipment

Concept design must be prepared and risk assessment must 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 must be identified. Control and power supply to these critical processes must be provided with adequate redundancy to ensure that plant performance standard is within operating licence requirements. Consideration must 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 must be supplied from separate sections of a switchboard. Failure of any single device must not prevent operation of more than one process equipment.

The plant must 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 must be physically grouped together and supplied from the same switchboard.

Switchboards must 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 must 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 must 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 must not need to use the standby generator to supply power.

E2.3 Standby generator

Consideration must 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 must be in accordance to AS/NZS 3010. Both the main incoming and the standby generator circuit breakers must be mechanically interlocked as per AS 3010 so that only one of them could

be ON at any time. A combined phase sequence and rotation meter must 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 must be provided on the outside wall of the switchroom to enable the switchboard to accept power from a mobile emergency generator. The panel must be stainless steel with padlock facility. The panel must 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 must 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 must be located close to the generator connection panel. Consideration must be given for vehicle access for setup and refuel the generator.

E2.4 Minimisation of hazardous areas and confined spaces

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

Installations must 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 must be performed as required in AS60079 and as specified in TG0502 - Classification and management of flammable gas hazardous areas.

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

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

Equipment	Preferred Techniques	
	Zone 1	Zone 2
LV Motors	Ex d	Ex n
Local Control Stations	Ex ed	Ex ed
HID Luminaries	Ex de	Ex de (Ex nR must not be used)
Fluorescent Luminaries	Ex e	Ex n (Ex nR must not be used)
Transmitters (4-20mA)	Ex i	Ex i
I/P Converters	Ex i	Ex i
Solenoids	Ex i	Ex i
Process Switches	Ex i	Ex i
Analysers	No preference	No preference

Changes to the dossier and classification (including the addition of new zones or equipment) must require the updating of the existing dossier. The production of a project specific dossier is not permitted.

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

The assumed maximum ambient temperature is 45^0C. All explosion-protected equipment must be certified for a T_{amb} of at least 45^0C. Written acceptance from the hazardous area committee must be obtained prior to using equipment not certified for a T_{amb} of at least 45^0C.

To reduce the effect of solar radiation, all electrical equipment must be protected from direct exposure to solar radiation by location, sunshields, etc. unless its T_{amb} rating is at least 70^0C, 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 must be submitted.

PVC glands must not be installed in hazardous areas.

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

E2.6 Power factor correction

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

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 must 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, arc flash hazards and operational flexibility. Ring or parallel feeders must 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 must have mechanical or key interlock to prevent parallel operation.

All power system related modelling and design work must be carried out by using SKM Powertools software compatible with clients' system. As a minimum, the system modelling must 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 must 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 Co-ordinations must 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 must also provide engineering mitigate methods to SWC for acceptance. The feedback from SWC must 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 must be submitted to SWC. The system model and associated outputs must remain the intellectual property of SWC.

Load centres must 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 must 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 must be provided. These would include switching, racking and earthing. The remote operation must 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 must be based on the latest IEEE 1584 and NFPA 70E standards, SCAs and MCCs have a rated nominal current equal or greater than 800A must be assessed for Arc Flash risk through modelling, the contributions of Arc Flash model must consider all energy sources including: Cogen system, diesel generator, solar system and etc., the motor load contributions for Arc Flash assessment must consider all loads equal or greater than 37.5kW.

The Arc Flash Assessment report must 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 must also provide

- Arc Flash labelling for each installation and area based on the assessment results showing:
    i. Incident energy level at working distances (Cal/cm^2) , minimum working distance (mm) and PPE requirements (Category Number) for every possible work activity
    ii. Date of the Arc Flash assessment
    iii. Arc Flash boundary (mm)
    iv. 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 must, 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 must be conducted and documented for all SWC machines. Assessment templates and a detailed assessment procedure must be produced by the designer.
- Maintenance requirements must 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 must not be used for isolation purposes
- Emergency stops must 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 must employ Cat 4 safety circuit as per AS 4024, emergency stops must not be adversely affected by electrical or electronic circuit malfunction
- The actuator of the emergency stop device must be coloured RED, the background behind the actuator must coloured yellow and placed as far away as practical from the actuator, the actuator of emergency stop must be non-locking, with a large emergency stop label comprising black letters on a yellow background.
- Resetting of the emergency stop must 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 must be based on SWC template circuit TE100E and the requirements of the latest issue of SWC Treatment Plant SCADA Standards
- For all other assets, the circuit must be in accordance with the latest issue of the SWC I&C Manual and must be accepted by SWC.

E2.9.2 Latch stop

Emergency stops that are not used for personnel safety must be referred to as latch stops to aid distinction as to their function and avoid any confusion as to purpose regarding the latest Work Health and Safety Act and regulations.

- They must include a red mushroom head button against a grey background, pull to reset, non-locking, with no label
- For Treatment Plant SCADA the circuits must be based on SWC template circuit TE100 and the requirements of the latest issue of SWC Treatment Plant SCADA Standards
- For all other assets, the circuit must be in accordance with the latest issue of the SWC I&C Manual and must be accepted by SWC. Where there is a conflict between this policy and relevant regulations or legislation, it is the responsibility of the designer to immediately notify SWC upon becoming aware of such a conflict.

E2.10 Harmonics and voltage distortion in the power supply system

The power supply system and equipment must 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 must comply with the Australian Standards and the requirements of the electricity distributor and must 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 must consider the impact of harmonics on the electricity distributor’s power network in the connection agreement. A harmonics study must 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 must be measured and documented before and after the commissioning of new and/or modified equipment.

If required, additional equipment must 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 must 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 must 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 must be fitted with latched stops. The latched stops must be distinguishable from emergency stops.

Emergency Stop / Latched Stop must be wired directly into the drive control circuit in series with the main contactor. When activated the Emergency Stop / Latched Stop must 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 must be directly hardwired to the MCC starter panel to provide protection in Auto, Manual and Field modes. The interlocks must 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 must 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
3. Suction safety and delivery safety switches for pumps
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
12. Bearing over-temperature
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 must 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 must not cause major alterations to any connected equipment. For a dual power supply facility, working instrument transformers on one power supply must 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 must be installed with a centre line between 200 mm and 1680 mm from the floor. The centre line of all indication devices must be mounted no taller than 1850 mm from the floor.

The design must 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 SWC sites, it is preferred for high voltage cables underground cables to maintain a minimum of 1,000 mm from other services.

The design must consider other utilities that may be installed adjacent to SWC property. Refer to the SWC 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.

E2.17 Solar PV System

The design and installation of Solar PV system must comply with SWC Technical Specification Solar PV, AS 4777 series and other relevant Australian Standards and regulatory requirements.

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 SWC's technical and operational representatives.

For Network assets all new low voltage switchrooms must be based on the current version of the SWC DTC LV switchroom drawing set (DTC3000-DTC3006). If the DTC is fit for purpose it must be used. Where modifications are required the DTCs and associated notes must 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 must 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. SWC reserves the right to request the designer and/or verifier to submit evidence of their certification. Sufficient verified drawings must be provided for interfacing and any council submission requirements for the structure.

Standalone permanent switchrooms must 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 must be provided. Consideration must be made to allow for room for maintenance and future expansion. Please refer to SWC 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 must be fire stopped. Switchrooms must be sealed and vermin-proof.

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

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

E3.1.1 Fire resistance

All switchrooms must 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 must 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 must be located in other walls. If a door is located within a wall which needs to achieve an FRL the door must be tested to the required rating.

Switchrooms located in bushfire prone areas must comply with the latest version of AS 3959 with additional measures undertaken for critical sites. These must be confirmed with SWC during the design stage.

Fire extinguishers suitable for electrical fires must be fitted in switchrooms at all treatment plants based on a site-specific risk assessment. The risk assessment must be carried out in consultation with SWC 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 must have a minimum of two exit doors, the follow door types must 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 900 mm wide x 2200 mm high clear opening or greater for personnel access.

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

For prefabricated switchroom, the doors must 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. Larger opening for access maybe required to enable entry of prefabricated switchrooms in accordance with AS 3000.

Doors must be designed and fire rated in accordance with National Construction Code (NCC) requirements.

Doors must be open to the outside and lockable from the outside only. The doors must be openable from the inside by turning the door handle independently of whether the door has been locked from the outside. Doors must be fitted with panic bar exit mechanisms to aid in emergency exit. Doors must 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 must 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 must be installed with split system air-conditioning unit(s):

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

Switchroom air-conditioning must 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°C
- Maintain humidity within acceptable limits
- Fully seal the room to exclude external contaminants
- For SPSs and STPs the external air conditioning unit must be heavy-duty corrosion-proof unit suitable for sewage gas environments.

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

The air conditioner and ventilation units must 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 SWC.

E3.1.4 Switchroom layout

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

Switchroom layout must 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 must 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 600 mm clearance passageway for evacuation even when removeable parts are racked out to serviceable position or door opened.
- The location of electrical cubicles must be arranged so that hot air from any other equipment/machinery is not directed onto the cubicles. Where possible, electrical cubicles must not be mounted on, or against the western wall of superstructures.
- Comply with AS/NZS 3000 requirements for clearance distance with adjacent equipment and building structures.

E3.1.5 Emergency lighting and smoke detector

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

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

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

E3.2 Permanent switchroom

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

Roof must 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 must be of non-combustible construction.

Switchrooms must 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 must be above the 1 in 100-year flood level. The floor of the switchroom must be above the ground level around the switchroom by 150 mm minimum and all conduits leading into the switchroom must be sealed to avoid water ingress to the switchroom.

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

Switchboards installed in switchrooms with infinite access floor must 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 must be a minimum of three metres and capable of housing all SCAs and MCCs when resting on 75 mm plinths, provided SCAs and MCCs do not have plinths as part of the switchgear assembly. The ceiling height must 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 must be regarded as Class 8 structures and are generally not considered to be habitable spaces.

E3.3.1 Design loads

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

The floor framing must be supported off the ground along the perimeter beams with steel columns, typically at centres of not less 2.0m. The floor frame design must allow for lifting with all the equipment installed in the switch room within the nominated deflection tolerances. Lifting brackets must be on the base-frame and must 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 must be in accordance with Clause 5 of SWC Technical Specification - Civil.

The support columns must be founded on reinforced concrete pads. The pad footings must 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 must be not less than 800 mm x 800 mm x 250 mm thick. The top of the pad footing must be located nominally 100 mm above the finished ground surface.

The minimum concrete grade for the pad footings must be N25 to Clause 3 of SWC Technical Specification - Civil.

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

E3.3.3 Steps, landing and access

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

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

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

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

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

All stringers, stairs and landings must be hot dip galvanised (HDG) in accordance with WSA 201 and SWC Supplement.

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

E3.3.4 Floor coverings and penetrations

The floor must 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 must be located in a recess and the recess must be filled cement grout on completion of installation.
- Has a fire rating that meets all the relevant requirements applicable to the application.

Floor penetrations must be designed such that maximum access is provided to equipment gland plates.

Structural members must cross the Switchroom floor at centres to meet engineering requirements. These members must be set at a depth below the floor equivalent to the height of the floor joists + the flooring material. These members must be located between panel joints and must not encroach into the cable zones. Floor joists must not encroach into any cable penetrations. All floor Penetrations must be placed between the floor joists.

E3.3.5 Walls, roof and ceiling

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

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

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

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

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

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

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

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

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

All external flashings must be fabricated from matching Colourbond flashing.

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

E3.4 Infinite access floor

E3.4.1 General

The infinite access floor system must consist of 600 mm 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 must be suitably treated to prevent corrosion or deformation due to the ingress of moisture or corrosive gases. The cut edges must be sealed with a manufacturer approved sealant.

The complete flooring system must be suitably treated to prevent corrosion or deformation from a humid salt laden atmosphere and corrosive sewage gases.

All components must 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 equipotential bonding points must be provided for the floor to connect to the local earth.

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

E3.4.2 Floor panels

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

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

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

The floor panels must 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 must be surfaced with a high-pressure laminate of 1.6 mm thickness conforming to Australian Standard AS 2924 "*High-Pressure Decorative Laminate - Sheets made from thermosetting resins*" and trimmed with extruded soft vinyl. The surface must 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 SWC for acceptance.

E3.4.4 Under structure

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

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

Each pedestal must provide a minimum ± 32 mm 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 must be provided on each pedestal.

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

The main vertical body of each pedestal must 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 must be formed of hot dip galvanised steel and be capable, without panels in place, of supporting a concentrated load of 120 kg at centre of a 600 mm span without exceeding 172 MPa stress.

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

Stringers must have a semi-conductive polyethylene plenum seal located on top of the member.

A manufacture recommended perimeter support system must 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 must be submitted to SWC for acceptance before any installation work will be permitted.

E3.4.5 Installation

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

The maximum level variations for the floor must be ±1.6 mm within 3 metres and ±3.2 mm over the whole installation.

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

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

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

The infinite access floor must be installed only after the switchboard frames are installed. The floor panels must 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) must be removed for access purposes, extra pedestal supports must be installed.

The pedestals or their base assemblies must 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 must 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 must be provided in the pits to separate instrument and power cables.

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

The pits must 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 must 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 must be lower than the switchroom sub floor and be drained away to avoid water entry to the switchroom. The sub floor of a switchroom must be graded to allow water flow to one end where there must 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 one metre must have approved non-corrosive step iron installation for safe access.

For new low voltage installations, each conduit run must have 50% additional conduits of each size installed for future use. Each pit must 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 must be at least one 150mm spare conduit for future use.

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

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

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

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

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

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

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

Bends must be at least 12 times the cable diameter and must be formed with proper formers. Correctly sized springs must 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 must be stainless steel double-sided for steel and PVC conduits. PVC saddles must not be used.

Saddles supporting conduits must 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 must be used. Saddles must 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 must be painted to prevent deterioration of the conduit due to exposure to sunlight. All fittings must be of the same material as the conduit and all joints must be made with an adhesive cement recommended by the supplier of contrasting colour.

E4.1.3 Rigid metallic conduits and fittings

All steel conduits must be galvanised ('heavy protection') with screwed joints and screwed terminations. End joints and terminations must 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 must have screwed ends and screwed joints, all threads being painted with aluminium paint. Steel conduits must be electrically and mechanically continuous.

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

Joints must be protected against corrosion and effectively sealed against entry of water or moisture and all associated fittings must be either galvanised steel or galvanised malleable cast iron. Bends must be of large radius. The pipe run must be electrically continuous and the enclosure must 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 must 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 must be galvanised medium quality pipe to AS 1074 (generally known as galvanised water pipe). Joints must be protected against corrosion and effectively sealed against entry of water or moisture and all associated fittings must be either galvanised steel or galvanised malleable cast iron. Bends must be of large radius. The pipe run must be electrically continuous and the enclosure must be earthed at both ends.

E4.1.4 Light duty PVC conduits and fittings

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

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

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

All standard size wall boxes must 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 must be effectively earthed. UPVC conduit must 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 must not be run in the concrete toppings. Conduits run in the fill under floor slabs must be HD-UPVC. Corrugated conduits are not permitted.

Conduits must 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 must 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 must 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 must not be less than the conduit diameter or 20 mm, whichever is larger.

Conduits must 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 must be 25 mm, spaced not less than 75 mm apart.

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

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

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

E4.1.6 Installation

UPVC conduit must 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, if they are suitably protected from mechanical damage and sunlight.

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

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

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

Conduits must 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 must be effectively capped during construction.

Conduits must be securely fixed to building members and must be adequately supported during all stages of building construction. Care must be taken to support PVC conduit upstand. Generally, all conduits must be concealed.

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

Directly buried conduits must 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 must be covered with stone free spoil removed from the trench. After laying the conduits in unpaved areas, the trench must be backfilled and consolidated to about 10 mm above the natural ground level. All excess spoil must be removed from the site.

Saddles supporting conduits must be effectively secured to the surface on which they are run. Saddles must 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 must be installed using saddle spacers clear of the surface.

Conduits must 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 must be used to terminate conduits into fittings.

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

All conduits and pipes for future use must be provided with polypropylene draw cords. A length of cord 1000 mm long must be left securely fixed at the ends of each run.

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

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

Draw-in boxes must 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 must 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 must be followed:

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

E4.2.2 Underground reticulation

To preclude damage, cables must 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, must 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 must 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 must be coordinated as indicated. Penetrations through damp courses will not be permitted.

Penetrations through Waterproof Membranes:

Conduits which enter a building at ground level must 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 must 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 10 mm greater than the conduit diameter must be provided. The penetration space around the conduit must be made waterproof by using a proprietary sealing method.

E4.3 Lighting

E4.3.1 General

Adequate lighting must 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 must comply with the requirements in AS 1680, AS 2293 and National Construction Code.

A detail lighting study must 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, must 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 must be industrial type and the following lighting type must 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 must be designed in accordance with the requirements of the Australian Standards.

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

All luminaries except external pole-mounted or high mast lighting must be installed in locations, which could be accessed with portable platform ladders not longer than 5 metres. It must 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 person.

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

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

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

1. Light switches must be of the flush type, fixed in wall boxes to suit the installation, and located at room and gallery entrances. Two-way switches must be supplied and installed for corridors and galleries.
2. Switch plates for switches must be impact resistant plastic mouldings, suitably reinforced, of selected colour and finish
3. Ironclad switches must have the toggle fully recessed or protected by shrouds
4. Switches exposed to weather, or in locations subject to dampness or condensation must be impact resistant, fully insulated, moulded plastic or cast metal, and must have a rotary action positive contact switch. The enclosure must be minimum IP56 and effectively sealed against the ingress of water or moisture.
5. Switch mechanisms, fitted to a flush plate, must be secured to the plate with retaining screws, or constructed so that switch mechanisms cannot be displaced.

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

Switches must not be installed across the junction of different wall finishes. Adjacent switches connected to different phases must be shrouded. Mounting heights for switches must be approximately 1200 mm to the centre of plate above floor level, unless otherwise indicated.

E4.3.2 Emergency lighting

Emergency luminaires must 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 must be fitted above exit doors. Emergency exit signs must be located such that at any location within the site there is uninterrupted view to at least one of them. The luminaires must be of the self-maintained, self-contained type with battery backup supply, in accordance with AS 2293.1. They must be tested using proprietary brand test station as per AS 2293.3. Size of backup battery must be sufficient for operation of 90 minutes in service and 120 minutes during initial commissioning.

E4.3.3 External lighting

External areas must be designed to the following:

- Minimum horizontal illuminance around plant and storage areas must be 3 lux. Where horizontal illuminance falls below this value in less important perimeter areas, the horizontal illuminance must be at least 1 lux and vertical illuminance at least 3 lux.
- Minimum horizontal illuminance on access road must be 1.5 lux with an average of 5 lux
- Floodlights must be cut-off type and not projector type to minimise glare or unwanted spill light into neighbourhood
- Exterior Vandal resistant light fittings must be provided over external doors.

Street lighting must be installed every 30 metres on incoming access roads.

E4.3.4 Security lighting

Security lights (building and street) must be automatically controlled by a light sensitive switch or photo electric cell (PE Cell). The PE Cell must be mounted on the exterior wall of the building facing a Southerly direction. A "Manual-Off-Auto" (MOA) selector switch must be supplied and installed at building exits for

each new building. The MOA switch must be located such that it is inaccessible after the building is locked up. When selected "Auto" the lights must operate by the switching of the PE Cell. When selected "Manual" the PE Cell must be overridden and the security lights must be switched on. When selected "Off" no operation of the security lights must be possible. The security lights must be minimum:

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

E4.4 General power

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

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

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

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

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

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

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

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

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

Generally, power outlets must 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 must be at a height of 1100 mm above finished floor level. In damp areas the requirements of the Wiring Rules are always satisfied.

E4.5 Fire detection and security equipment

Fire detection system and alarms must 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 must provide detection and local alarm only.

A security system must 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) must be provided for all gas hazardous area(s). The alarm signal must be wired to the IICATS and plant SCADA system. The control panel must be installed outside the gas hazardous area. Upon detection of gas, the system must shut down the electrical power supply including batteries and UPSs.

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 AS 2067. 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 must be in accordance with AS 3000 and AS 3017. Relevant earthing test and verification must 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 must 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 must 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 must be at the ends of the bar
- Main earth and neutral connections must have a minimum of 50 mm 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 must be copper plated or copper clad steel, and must 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 must not be used unless otherwise detailed.

The connection at the top of all earth electrodes must be installed in appropriated sized pits and the pit covers must comply with E4.1.1.

All earth electrodes must 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 must 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 must be bonded to earth. The equipotential bonding conductor must be a minimum of 4 mm² earth wire.

All conductive cable ladder sections must 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 must provide protection against lightning strikes covered in AS 1768 section 1.1.

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

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

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

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

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

Removable test links must be installed in every down conductor.

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

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

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

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

Testing must 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 must be provided to SWC.

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 must 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 must 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 must be designed and installed in accordance with AS 2067.

All power system studies must 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 must comply with SWC High Voltage Operating Procedures.

E5.2 Equipment specification

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

No.	Reference	Description
1	DOC0012	HV Switchgear
2	DOC0014	Protection Relays
3	DOC0008	Batteries and Chargers
4	DOC0019	Power Transformers
5	DOC0020	Prefabricated (Kiosk) Substations
6	DOC0011	HV Power Factor Correction
7	DOC0010	HV Motors
8	DOC0015	HV Motor Starters
9	DOC0016	Earthing and Lightning
10	DOC0018	HV Switchroom
11	DOC0009	HV Electrical Cable
12	DOC0017	HV Overhead Line Equipment’s
13	DOC0270	HV Installations

E6 Not Used

E7 Not Used

E8 Not Used

E9 Low voltage switchboard and motor starter

E9.1 General

This covers the 400 V 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 must 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 by SWC. Upon acceptance of the final Arc Flash assessment results, labels must be fitted to the SCA indicating related PPE level, appropriated working distance and arc flash boundary.

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

Switchboards with two incoming supplies must be separated into two sections via a bus tie. All process drives must 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 must be provided (see clause E2.7).

If on-site generators are designed to connect to a switchboard, the following generator related signals must 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 800 A per phase for power distribution, and isolation switches for drive size from 250 kW (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 must be constructed and tested in accordance with the requirements of AS/NZS 61439.1. Form 3B or Form 4 assembly must be used if the nominal supply current to the switchboard is 800 A or more per phase, The SCA must 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 in accordance with AS/NZS 61439.1 Section 10.

For any component of the SCA rated greater than or equal to 800 A, that entire SCA must have internal arcing fault tests in accordance to AS/NZS 61439.1 Appendix ZD including the special tests in ZD6. Internal arcing fault tests to the latest edition of IEC TR 61641 can be accepted subject to SWC's prior approval.

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

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

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

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

The door handles must be Selectrix TL818 (or equivalent) with three-point locking.

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

The SCA must be built up from several free-standing cubicles bolted together to form a rigid assembly. All cubicles forming the assembly, irrespective of the equipment to be accommodated, must be of uniform height and depth. The fronts of the cubicles must, as far as practicable, be of similar construction so that the complete assembly presents a uniform appearance.

The SCA must be designed and constructed to allow future expansion by addition of sections at either end. The busbars must be arranged so that a minimum of downtime is required to connect an extension panel.

E9.3 Outdoor SCA

SCAs that are permitted to be installed in an outdoor environment must 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 must comply with all indoor SCA requirements in Section E9.2. In addition, Outdoor SCA must comply with following elevated requirements.

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

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

The degree of protection against the ingress of foreign bodies must be a minimum of IP54 for outdoor SCAs.

Outdoor SCA's and all components must be designed to suit maximum ambient temperature of +55°C, and maximum 24 hours average temperature of +35°C.

Variable speed drives rated up to 22 kW can be installed in outdoor SCA subject to satisfactory heat dissipation calculation confirming temperature requirements.

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

E9.4 Motor starter

E9.4.1 General

Each motor starter must 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-temperate 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 must be either 1 A or 5 A moving iron with a Class 1.0 metering CT in starters rated more than 30 A

b) The triple pole main contactor must have minimum two normally open and two normally closed auxiliary contacts

c) Three phase thermal overload and relay system. The protection relay must be auto-resetting. Latching must 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 must 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 must have a normally open auxiliary contact wired out to the terminal strip.

k) VSD 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 must incorporate under speed sensor relays or motion detectors for drives as required by the process.

If digital protection relays are proposed, they must be based on models currently used by SWC. 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 SWC acceptance.

In addition, starters must comply with the Treatment Plant SCADA Standards and associated standard template drawings and schematic diagrams. If smart starters are proposed, they must be the type approved by SWC and comply with SWC's standard template drawings for smart starters.

E9.4.2 Stand-alone motor starters

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

The degree of protection against the ingress of foreign bodies must be a minimum of IP54 (IP52 for air conditioned switchroom) for indoor units and IP56 for outdoor units.

Stand–alone motor starters in network installations must be provided with Modbus/RS485 interface to communicate with IICATS.

E9.4.3 Isolators

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

All isolators must 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 must be pad lockable in an OFF position using a standard padlock or a multi-locking device.

Isolators must be mechanically rated to a minimum of 30,000 no-load operating cycles. A utilisation category must 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 must 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 must 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 must be identified as red/white/blue top to bottom, left to right or front to back. All busbars must be tinned. The busbars and joints must be sealed or shrouded to the requirement of the electricity distributor. The busbar must only carry the weight of the cable within its designed withstand mechanical load in accordance with AS 61439.8, cables must be independently support if they exceed the busbar withstand mechanical load limit.

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

E9.5.2 Earthing

An earth must 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 must 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 must be carried out in compliance with AS/NZS3017 and the value must be recorded in the relevant documentations. MEN links must be provided.

E9.6 Internal wiring

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

Cable number must consist of the following:

- A number, which must 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 must 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 must 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 must be as follows:

Item	Wiring and/or conductors	Colours
Phase	Red Phase White Phase Blue Phase Neutral	Red (R) White (W) Blue (B) Black (BK)
Earthing		Green-Yellow (G-Y)
230 V AC control: When supplied from the same compartment or SCA In all other cases	Active Neutral Active Neutral	Brown (BN) Black (BK) Orange (O) Black (BK)
CTs & VTs secondaries	Red Phase White Phase Blue Phase Neutral	Red (R) White (W) Blue (B) Black (BK)
Extra Low Voltage (AC or DC)		Light Grey (LtG)
Conductors connecting voltage free relay contacts where the voltage is undefined		Violet (V)
Sheath of double insulated cable for Intrinsically Safe circuits		Light Blue (LtB)
Instrumentation twisted pair conductors	Positive Negative	White (W) Black (BK)

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 must be 25 mm wide heat shrink bands of the colours specified in this clause applied at each end.

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

Each end of all conductors must be identified with white thermoplastic interlocking ferrules with machine printed black and red characters. Ferrules must be sized to fit conductor insulation and installed at every terminal. Each cable core must 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 must utilise alternate phases.

E9.7 Labels

A nameplate must be fixed to the SCA with its designation. Location number must be included in the nameplates and labels.

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

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

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

Safety signs and danger labels must comply with AS 1319.

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

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

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

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

All lettering engraved on labels must be in block capitals.

All labels for panel mounted electrical components must 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 must be similarly identified.

The manufacturer's data plate must 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 must 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 must be provided with a data plate on the inside of each module that must 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 must be made of non-corrosive metal plate with engraved inscriptions. The nameplate must be fixed in position by M3 chrome plated screws, nuts and washers and must be clearly visible from the access position.

E9.8 Functional units and cable zones

New SCA's must be provided with 15 % spare modules for future use. These modules must be fully functional units equipped with take-offs, circuit breakers, fuses and equipment slide rails. The bottom module of each tier must 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.

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

Each module must 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 must only be possible after power has been turned off.

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

All door and cover fastenings must 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 must be provided with neoprene sealing gaskets manufactured for sealing purposes. The use of foam plastic materials is not acceptable. Removable panels or covers must be provided to give access to busbar zones. These panels must not be hinged and must be fitted with warning labels "DANGER - LIVE 400V BUSBARS". The labels must be white lettering on a red background.

Cable zones must be provided to route power and control cables to the functional units. Cable zones must be minimum 400 mm width. Access must be available to the cable zone for installation and maintenance

work without exposing the busbar droppers. Cable entry into the cable zone must be from below. Power and control cable connection points must be in the cable zones adjacent to the respective functional unit. The connection points must be fully shrouded terminals and the need to terminate outgoing cables within the module is not acceptable.

All gland plates must be 5 mm thick aluminium with cable glands. Where single core cables are proposed, supporting clamps and cleats must 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 must 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 must 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 SWC. This includes painted murals.

E9.10 Circuit breakers

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

All circuit breakers must comply with AS 60947.2. Circuit breakers for incoming feeders must 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 must be moulded case circuit breaker with adjustable fault current protection. Moulded case air circuit breakers must have positive physical indication of the "tripped" position. The circuit breakers must 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 must be of non-welding alloys and all metal parts must be treated to prevent corrosion.

All circuit breakers must 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 must 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 must 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 must 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 must comprise stranded, 6.0 mm^2, and green/yellow PVC insulated cable installed such that it is segregated from all other cables.

Equipment housed in the SCA must be protected against mains voltage switching and lightning surges by shunt surge protection units installed on each incoming supply. Each surge protection unit must be an

enclosed three phase device including several 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 must 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 45 kA
- 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 must 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 must 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 must monitor all phases of the circuit they are protecting. The phase failure relays must 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 must have voltage free contacts wired to readily accessible terminals. The relays must 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

The selection and installation of panel meters must not violate the switchboard AS 61439 compliance and internal arcing fault test compliance if applicable.

Ammeters and voltmeters must be provided on the incoming feeder(s) to the switchboard. They must 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 must be provided on the line of all incoming feeders. For mobile and/or permanent generator connected feeder, there must be separate voltmeters connected on both line side and load side of the main switch, and the ammeter for generator main switch must be connect on the line side of the main switch.

Ammeters and voltmeters must have an accuracy class of 1.5.

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

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

Ammeters and voltmeters must be 96 mm non-flush mounting, square pattern industrial grade instruments with a 90º deflection movement. Scales must include a red mark indication of motor full load current.

The use of digital meters must be acceptable subject to the acceptance of SWC.

E9.14 Current transformers

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

The data plates of current transformers must 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 must be provided and fixed adjacent to the current transformers.

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

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

E9.15 Contactors

Contactors must 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 4 A 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 must be equipped with an over temperature relay(s) suitable for use with PTC thermistors supplied with motors.

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

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

E9.17 Motor protection relays

All motors must be protected from overload, phase unbalance and faults with motor protection relays. Motors less than 75 kW must be fitted with bimetallic thermal overload relays. Motors 75 kW and above must 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 must 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 must be DIN rail mounted, they must have flat pin design, test button, LED indication. The relays selected must have cross compatibility with other manufactures' relays and/or base.

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

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

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

Relays forming part of 24 V DC control circuits must 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 100 m) 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 must be demonstrated to SWC satisfaction that the design accommodates this consideration.

E9.19 Timers

All timers must 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 must 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 must comply with AS/NZS 60269 and AS 61818. Fuse holders must be fully shrouded. All circuits, including starters potential and control circuits, must 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 must be:

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

All lamps must 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 must 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 must 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 must 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 must be sinusoidal and as such no motor de-rating must be applied when operated at rated speed and load
- Acceleration and deceleration time must 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 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 must be according to Treatment Plant SCADA standard and associated standard templates drawings and schematic diagrams.

E9.22.2 Electronic soft starters

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

The starters must comprise of:

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

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

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

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

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

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

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

The starter must be suitable for three phase induction motors.

The starter must 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 must be within the limits stipulated by the Australian Standards/electricity distributor. Full installation instructions for the equipment, referring to electromagnetic interference reducing practices must be provided in clear English text. Noise suppression filters, if required to meet EMC Standards, must be supplied. Screened power cables must be used for VSDs.

EMC Filters must 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

Where VSDs are utilised on the site, a harmonics distortion measurement must 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 must be included in the Concept Design Report. On completion of the same tests must be completed with the maximum number of VSDs running. These results must be submitted to the SWC 2 weeks after completion. The Report must contain all measurements, supporting calculations, diagrams and information. Prior agreement with SWC must 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 must 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

Harmonic filter(s) must 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.

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

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.

In addition to item (d) above, a VSD solution must 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.

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

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 must be ensured that operation of the starter must 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:

- 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 must 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 must be maintained, the motor must 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 must be activated and the motor must then be allowed to automatically restart providing the external automatic control circuit requires that to occur. This fault must bring up a 'General Fault' light on the Starter Panel.

Appropriate wording of fault indication lights and reset labels must 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 must be suitable for use on a 24 V DC control system, unless specified otherwise.

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

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

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

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

All panels must 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 must be continuous. Tack welding will not be accepted.

Each transport unit must 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 must be provided.

All other requirement must be as per LV SCA requirements.

E9.24 Auxiliary distribution boards

Auxiliary distribution boards must be designed and constructed in accordance with AS 61439 series. Cabinet must 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 8 mm square drive. Cable entry to auxiliary distribution board must be via bottom only. All metal part of the cabinet must be bonded to earth. The cabinet must 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 must be an encapsulated chassis type, with rail mounted circuit breakers. Where specified, must 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) must be fitted.

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

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

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

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

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

Final sub-circuits must 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 must 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 must be transferred via a digital/serial communication to the plant SCADA system.

If the Treatment Plant SCADA Standards are not applicable, the following signals must 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 must 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 must 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 must be located in the main power distribution centres for the Plant and be integrated into the existing plant power distribution system. The switching steps must be designed to ensure that the power factor must 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 must 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.) must 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 must be provided with an external fuse of the current limiting type in each phase. The fuse must be suitable for use in air and must be provided with a striker pin.

All test results must be submitted as evidence of performance

E10.2 Enclosure

The power factor correction cabinet must have the following features:

- Manufactured on a minimum 2 mm 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 must be chrome plated pintle type.
- Up to 900 mm high must have 2 hinges
- Up to 1200 mm high must have 3 hinges
- Equal to or greater than 1200 mm high must 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 must be shrouded such that no live parts are accessible from the front of the enclosure with the door open
- Terminals for all internal components must be accessible from the front of the cubicle (with shrouds removed).

E10.3 Painting

The surfaces must 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 must be:

Interior: white

Exterior: aqua B25

E10.4 Capacitors

Capacitors must comply with the requirements of AS/NZS 3000 and the New South Wales Service and Installation Rules.

Each capacitor unit must:

- Be rated for connection to a 400 V, 50 Hz supply and where used with detuned (blocking) reactors, must be rated at a minimum of 525 V
- Be three-phase
- Be low loss dry type with self-healing dielectric. Maximum loss 0.5 W/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 must comply with the Australian Standards. Type test certificates must be available on request.

The reactors must:

- Be rated for series connection in a detuning circuit tuned to 189 Hz, for operation on a 400 V 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°C.

E10.6 Control relay

The unit must be fitted with an automatic power factor control relay mounted on the front door of the cubicle. The relay must include the following features:

- Suitable for connection to and control of 400 V, 50 Hz 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 must comply with Service and Installation Rule NSW. The power factor correction unit must 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 must match to ensure smooth, positive starting, in conjunction with the starter used, under all operating conditions.

Motors driven by variable speed drives must be specially designed for use in variable speed operation. They must 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 must be fitted with lifting lugs or eyebolts.

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

For motors 100 kW and above, illustrations and drawings giving complete motor winding diagrams and a diagram of connection for every coil showing terminals, wire sizes etc. must 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 must 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 must also be non-overloading at minimum (flood) head condition. The motor rating must 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 must be automatically activated after an adjustable time delay.

In order to reduce the wet well operating volume and control levels, the electrical equipment must be capable of minimum 12 starts per hour for each pump.

E11.3 Motor

Each motor must 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 must be IPX8 and fitted with moisture detection in the motor stator housing and the cable termination housing. Pump seal failure detection must be provided for motors of size 7.5kW and above. Submersible motors must 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 must be suitable for use under water and must have an outer sheathing to protect it from damage. The cable must also have a stranded 316 stainless steel supporting cable, which must 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 must be provided as required or a separate cable must be supplied for thermistors. The turret/s must be installed adjacent to the wet well and must 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 must 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 must have an anti-corrosion finish.

Each motor must be manufactured in accordance with the latest issues of AS 60034 series.

The motor must have Class F winding insulation thermal class, must be maximum continuous rated and must 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 must not exceed 7 times the rated full-load current.

The continuous rated output of each motor must 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 0.73 kW and 185 kW must be "high efficiency" motors complying with minimum efficiency requirement as specified in AS/NZS 1359.5.

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

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

E11.4 Terminal boxes

Terminal boxes must 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 must be brought out to suitable fixed terminals, preferably stud type, located within the main terminal box.

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

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

E11.5 Bearings

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

Motor bearings must 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 must be taken to ensure that any insulation is not short-circuited during motor assembly. The driving end bearing must be earthed via a removable copper shunt.

E11.6 Motor testing

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

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

E11.7 Temperature protection

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

The requirements of bearing temperature protection for large motors (600 kW and above) are covered in SWC Technical Specification – Mechanical, Section M5.

For motors smaller than 600 kW, resistance temperature devices (RTD) and/or thermal switches must 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 must be in accordance with the Treatment Plant SCADA/IICATS Standards and associated standard template drawings and schematic diagrams.

All thermistor/Pt100 leads must 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 must actuate a compatible tripping relay for its speed at a tripping temperature in accordance to thermal class rating in AS 60034 series. The resistance of each device supplied must be 1000 Ω at the tripping temperature, as specified above, for the class of insulation employed.

In addition to the nameplate of the motor, a nameplate must 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 must be rated for continuous operation and must perform to the Specification when operating within the whole range of ambient temperatures and relative humidity. Actuators installed outdoors must 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 must have corrosion protection for aggressive sewage atmosphere with high humidity and high concentration of pollutants.

The maximum number of starts per hour must 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 must 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 must be provided.

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

The actuator and gearbox assembly must 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 must be rated, designed and sized to safely operate over the full range of valve/penstock operating conditions. The actuator and gearbox combination must 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 must 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 must be equal and adjustable. Unless otherwise stated in the Project Specific Specification, the open-to-close and close-to-open times must be:

Valve size	Open-to-close/close-to-open time (seconds)
Up to DN200	20 - 30
DN250 - DN400	60 - 90
DN450 - DN900	180 - 270
DN1000 - DN1200	300 - 450
Larger than DN1200	500 - 750

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

The opening/closing time for penstocks must be as specified in the project specific Specification.

E12.2 Mechanical requirements for electric actuators

E12.2.1 General

The actuators must be installed on the top of the valve/penstocks or valve pedestals (extension spindle shrouds) and must be capable of being rotated through any 90° quadrant as a complete unit.

The actuator must 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 must be on the input side of the drive and not the output shaft.

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

For network installations, where specified, the control unit of the actuator is preferred to have lockable blind plate compatible with SWC padlock.

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

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

E12.2.3 Bearings

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

E12.2.4 Lubrication

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

E12.2.5 Hand wheel

The actuator must be equipped with a hand wheel for manual operation. The hand wheel drive must be connected by means of a clutch mechanism, which also declutches the electric motor drive. The mechanism must 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 must be automatically uncoupled.

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

The actuator must 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 must exclude operation by the other mode.

Should the actuator seat on very high torque or stall then it must 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 must not exceed 160 N at the hand wheel rim.

The hand wheels must be positioned as specified in the Technical Specification - Mechanical.

E12.2.6 Mechanical position indicator

The actuator must 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 must 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 must 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 must have integral motor starter unless otherwise specified in the Project Specific Specification.

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

Unless otherwise specified in the Project Specific Specification, the actuator, motor, limit and torque switches, and associated control equipment must have degree of protection IP68 in accordance with AS 60529, suitable for immersion in 5 metres of water for 72 hours.

Integral actuators must 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 must be modular in that it may be easily retrofitted to an existing actuator in the field.

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

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

E12.3.2 Duty rating

The actuator and motor must be rated for a minimum of three 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 must be either contactor or semiconductor, Direct-On-Line, or variable speed, reversing type, electrically interlocked and complying with the requirements of AS 60947.4.1 and AS 60947.4.2 respectively and must 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 must not latch out in case of a power failure, i.e. when power is restored all circuits must 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 must stay still pending receipt of an "OPEN" or "CLOSE" instruction.

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

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

E12.3.5 Fault condition for integral actuator

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

COLLECTIVE FAULT (VALVE/PENSTOCK FAILURE)

The collective fault signal must 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 must 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 must be submitted for acceptance.

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

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

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

Limit switches must be able to be adjusted from the front of the actuator.

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

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

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

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

1. One contact which must close when the valve/penstock is in the fully closed position
2. One contact that must 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 must be as given in the table below.

INDIVIDUALLY ASSIGNABLE LIMIT SWITCHES (NON -SCADA CONTROL)

Item No	Number of assignable switches	Assigned function
1	One (1)	Actuator Common fault
2	Three (3)	Fully Opened
3	Three (3)	Fully Closed
4	One (1)	Opening
5	One (1)	Closing
6	One (1)	Control disabled (refer Note 1 below)

Note:

1. The Control Disabled alarm must 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 must operate in a "failsafe" manner.

E12.3.7 Position transmitters

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

E12.3.8 Torque switches

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

Each torque switch must have voltage-free contacts rated at 0.5 A, 24 V DC.

The torque switches must be made of brass. Plastic switches will not be acceptable unless prior acceptance has been given by SWC.

The torque switches must be totally sealed and permanently wired to prevent ingress of moisture. There must 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 must have the following mode selection and control:

Mode selection of the actuator must be done via SCADA, mode selector switch integral to the actuator must be removed. Where it is not possible to physically remove the mode selector switch, its function must be disabled and physical use of the selector mechanism must 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 must be disabled when the actuator is in “REMOTE” mode and enabled when the actuator is in “LOCAL” mode. If this is not possible, they must 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 must be disabled and physical use of the button mechanism must 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 must 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 SWC 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 must be Profibus and must have the following features:

1. It must be possible to set a bit within the actuator program or parameter set that determines whether it is "Maintained" or "Non-maintained"
2. It must 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 must continue transit until the limit is reached. If the actuator is "Non-maintained", it must stop dead.
3. When Profibus comms is healthy, the ability to use the actuator mounted open/close/stop buttons must be determined by the remote enable bit. When Profibus comms is failed, the actuator mounted open/close/stop buttons must be enabled. If the comms fails during transit and the actuator is "Maintained", it must continue transit until the limit is reached. If the actuator is "Non-maintained", it must stop dead.
4. When Profibus PLC bit is healthy, the ability to use the actuator mounted open/close/stop buttons must be determined by the remote enable bit. When Profibus PLC bit is failed, the actuator mounted open/close/stop buttons must be enabled. If the PLC fails during transit and the actuator is "Maintained", it must continue ran sit until the limit is reached. If the actuator is "Non-maintained", it must stop dead.

5. It must 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 must be possible to connect a hardwired voltage free contact as a process interlock directly to the actuator. When the circuit is open, the actuator must be inhibited from operating. When the circuit is closed, the actuator must operate normally. When the process interlock is activated, the operation of the actuator must 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 must 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 must be provided with the pushbuttons. Where the actuator has a modulating or mid-position function, the percentage open must be provided with the pushbuttons. The operation of the pushbuttons for opening and closing at the remote location, must 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:

Valve/penstock type	Integral starter	Plc failsafe to open or closed position	Maintained running on plc failure	Drawing template
2 -position				TE150
2 -position		□		TE150F
2 -position	□			TE154, TE154LI (with line isolator)
2 -position	□		□	TE154M
Modulating				TE150Z
Modulating		□		TE150ZF
Modulating	□			TE154Z

The actuator must 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. must be voltage free contacts rated at minimum 0.5 A, 24 V DC.

12.3.9.2 IICATS control

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

The “LOCAL/OFF/AUTO” control selector switch and the “LOCAL” hand station must 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 must 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 must 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 must 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 must match to ensure smooth, positive starting.

The motor must 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 must be capable of 3 continuous opening and closing cycles.

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

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

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

The motor must form an integral part of the valve/penstock actuator and must be manufactured in accordance with the relevant parts of AS 1359.

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

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

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

E12.4.2 Terminal connections

The actuator motor and wiring must 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 must be connected to the actuator via plugs and sockets or terminals. The plug/terminals housing must be suitable to be indexed to allow for various cable entry orientations.

E12.4.3 Anti-condensation heater

The motor must have an automatic PTC controlled self-regulating anti-condensation heater, which must 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 must be embedded in each of the three phases of the motor winding. These devices must be wired in series to stop the motor whenever they are operated.

The temperature sensing devices must actuate a common tripping relay at a temperature of 155° for Class F insulation and must have a characteristic in accordance with AS 60034 series. The resistance of each device must be 1000 Ω 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 must 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

Valve/penstock Type	Integral starter	Plc failsafe to open or closed position	Maintained Running on plc failure	Drawing template
2 -position				TE150
2 -position		✓		TE150F
2 -position	✓			TE154, TE154LI (with line isolator)
2 -position	✓		✓	TE154M
Modulating				TE150Z
Modulating		✓		TE150ZF
Modulating	✓			TE154Z

The actuator must 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. must be voltage free contacts rated at minimum 0.5 A, 24 V DC.

For actuator with integral starter

The mode selector switch and open/close buttons and functions on the integral starter must be removed or disabled permanently. (i.e. the valve/penstock must 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 must be disabled and physical use of the selector and pushbutton mechanism must 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 must have the following mode selection and control:

For actuator with integral starter

The "LOCAL/OFF/AUTO" control selector switch and the "LOCAL" handstation must 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 must 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 AS 4024.1.

For actuator with non-integral starter

The "L1/L2/OFF/AUTO" control selector switch must 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 must 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 must be available.

Local manual control at each valve/penstock must 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 must 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 must be initiated by selection of "AUTO" at the control selector switch.

Valve/penstock opening and closing cycles must 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

Valve/penstock type	Integral starter	Control requirement diagram
2 -position		SSD/70
2 -position	✓	SSD/73
Modulating (Digital Positioning)		SSD/71
Modulating (Digital Positioning)	✓	SSD/74
Modulating (Analogue Positioning)		SSD/72
Modulating (Analogue Positioning)	✓	SSD/75
RTU I/O List for all electric actuated valve/penstock types	All valve/penstocks	SSD/67

The actuator must 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. must be voltage free contacts rated at minimum 0.5 A, 24 V DC.

E13 Pneumatic valve actuators

Where pneumatic actuators are used for opening and closing valves the pneumatic cylinders construction must have aluminium bodies, steel shafts and grade 316 stainless steel trim/fastenings and must be suitable for operation from a compressed air system with a pressure range between 550 kPa and 1000 kPa. Pneumatic cylinders must 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 must be multi - stranded. All cable and earthing conductors, cable trays, ducts and conduits must comply with AS/NZS 2053, AS/NZS 3000 and AS/NZS 3008. They must also comply with *Telecommunications Cabling Provider Rules* from ACMA for a control system connected into Telstra communications system.

All cables must be easily accessible for replacement. All cables and/or conduits must 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, must not exceed one metre between centres.

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

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

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

In switch rooms and plant rooms with cable trenches, all cables must 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 must be used for all cable routes whereby the main cable routes must be wall mounted “overhead” and at least 2100 mm above the finished floor level.

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

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

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

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

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

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

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

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

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

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

All cables installed above ground and external to buildings must be installed in cable trays with the final connection to equipment in heavy duty flexible conduit.

All cables must 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 must apply to submersible pumps, where the cable must be terminated with a plug/socket or terminal box to facilitate removal of the pump.

All cable cores must 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 must 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 must 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 type 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 must have sufficient length to permit replacement of a lug. For all other cables adequate slack must be provided at each end to allow for at least two re-terminations and connections.

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

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

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

Cables must not be bent in a radius less than 12 times their outside diameter.

The number of cables in ducts and the like must 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 must be in conformity with the requirements of AS/NZS 3008 and its derating factors.

Cables on ladder trays must not exceed three layers and must 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 must not exceed three layers.

Unless otherwise indicated, copper conductors must be used throughout.

The minimum size of conductors must 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 must be maintained, at all terminations of cables throughout the installation.

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

Field cable distribution from the main cable routes must be along the shortest route to the field termination and/or pull boxes.

Cable routes mounted along or across access ways must not present a hazard to vehicular traffic, cranes or personnel using these access ways.

All decommissioned cables must 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 must 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 must be circular section orange PVC/PVC and must have colour coded cores and earth conductor and be multi-stranded copper conductors and must comply with AS/NZS 5000.1 or AS/NZS 5000.2.

Screened power cables must be used for variable speed drives and have black or colourless (clear) sheath.
230 V Multi-core Control Cables

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

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

E14.4 Extra low voltage cables

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

Where the ELV cable is connected to a battery, the cable must comply with AS 4044.

E14.4.1 Single-pair cables (Instrumentation) for field wiring

Instrument (4 - 20 mA) signal cable must be twisted pair, with multi-strand copper conductors. Minimum size of conductors must be 7 / 0.50 mm (1.5 mm^2). The cores coloured white (positive) and black (negative).

E14.4.2 Multi-pair cables (Instrumentation) for internal wiring

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

Conductors must be of copper, with minimum size of 7 / 0.30 mm (0.5 mm^2). Each pair of conductors must have black and white coloured cores. The white core of each pair must have numbers printed on the insulation at intervals of not more than 100 mm.

E14.4.3 ELV power cables.

ELV power cables must be multicore cables with integral earth. The white core of each pair must 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 must be blue sheathed from the barrier to the equipment in the hazardous area.

Cables entering hazardous area Zone 0 or Zone 1 must be armoured.

E14.6 Cables for Exd application

Cables connecting Exd equipment (e.g. motors) must be steel wire armoured.

E14.7 Communication cables

Communication cables for Modbus or similar application must comply with the requirement in SWC IICATS specification.

E14.8 Labelling and identification

All power cable cores must be identified at each termination by the appropriate red, white and blue phase colour, and black for the neutral.

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

All cable cores including neutrals and spares must 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 must be in accordance with the cable schedules and/or interconnection wiring diagrams.

E15 Electrical installation

E15.1 Work on HV equipment or in HV area

Please refer to Clause 5 in relation to the requirements on installation work on high voltage equipment or in HV area.

E15.2 Materials and workmanship

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

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

All external materials must be corrosion resistant and must 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 must be obtained by the installer and submitted to SWC before the electrical installation will be considered complete.

E15.4 Site assembled equipment

Where the installer is required to site assemble electrical equipment, he must be responsible for all levelling and alignment. The installer must 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 must be responsible for supply and delivery of all materials, appliances and fittings required for the work on site and must be responsible for storing, cleaning, protecting against damage and preserving all material.

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

Installer must:

- Ensure that working and storage areas under his control are always kept clean and tidy
- 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 must 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 must be isolated, if necessary, by disconnection, from the part being welded.

Instrument type low voltage cables must 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 must:

- 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 SWC acceptance (the Plant Manager AND an appropriate SWC 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 must 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 SWC “Redundant equipment” tag attached at both ends
- Equipment made redundant must be reflected in the relevant drawings.

E15.8 Mechanical protection

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

- When mounted within 1.5 m 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 must be installed in galvanised steel water pipe. Conduits requiring mechanical protection must be galvanised steel water pipe.

Sheet metal covers installed to provide mechanical protection of electrical equipment must 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, must be constructed of minimum 2 mm 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 must be constructed to totally enclose such electrical equipment and associated conduits and/or cables.

Any device for the mechanical protection of conduits and/or cables must be free of burrs and sharp edges. Additional bushing, sleeving or other means must be provided as required to prevent conduit and cable damage.

E15.9 Sealing

Installation work must:

- 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 must be used for switchrooms.

E15.10 Supporting, mounting and positioning

All electrical equipment must be located, arranged, mounted and positioned so that it is readily accessible for operation, inspection, replacement, modification and maintenance without the use of scaffoldings and / or machineries like cranes, cherry pickers etc. To enable removal of equipment weighing more than 20 kg, provision must be made to enable lifting of equipment with the use of a lifting device. Consideration must 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 must not be shared with any other services.

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

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

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

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

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

Cutting of holes by burning methods must not be acceptable.

All mounting supports, brackets, plates and the like used for the mounting of electrical equipment must 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 must be of the correct size and length.

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

All electrical equipment mounted along or in access ways must 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., must be installed in locations that do not interfere with the normal operation and maintenance of the plant.

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

Fibre or nylon washers and mounting pads must 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 must 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 must 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 must be double sided stainless steel, fixed with stainless steel screws. Single sided saddles must not be acceptable.

Special care must be taken when saddling single core cables or conduits containing single core cables. Ferrous saddles must not be used when fixing such cables or conduits to metal structures. Care must 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 must firmly clamp, without distortion or damage, such conduits and cables.

Saddles, junction boxes and the like must 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 must be used.

Sufficient length of waterproof flexible conduit and/or cable must 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 must be of the plastic sheath, smooth, PVC spiral reinforced type and must be oil resistant, UV resistant and impact resistant. The fittings must 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 must be in stainless steel grade 316 to remain unpainted. Fibre or nylon washers and mounting pads must be fitted between metal washers and materials being fixed or joined.

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

E15.12 Terminal boxes

E15.12.1 Control cabinet terminal boxes

All control cabinets must have a minimum of IP52 rating. Material must be either 2.0 mm (minimum) hot-dipped galvanised sheet steel or 1.5 mm (minimum) 316 grade stainless steel.

The control cabinets must be provided with side hinged door with a minimum of 120° opening for access, the door must be provided with a suitable operating handle equipped with locking facility based on the application.

All doors and removable panels must 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 must be bonded to earth to create equipotential.

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

The control cabinet must 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 AS 3000. A person working on an extra low voltage circuit must not be at risk of touching a low or high voltage circuit.

Cables and wiring must not share common ducts.

Any deviation must be highlighted to SWC.

E15.12.2 Junction boxes

All junction boxes must have a minimum of IP55 rating. They must 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 must be coated in a grey-scale acrylic paint for further UV protection. Cable entries must 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 must be supported on galvanised steel brackets with a designed load of 75 kg per square metre. Cable ladder trays must have supports at joints and intermediate supports at not more than 2 m centres. Brackets must be spaced so that the loaded cable tray and ladder deflection does not exceed 5 mm.

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

Galvanised steel must be used for indoor and general outdoor environments. Marine grade aluminium must 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 must be considered.

All supports, fittings, brackets, bolts, nuts and washers must match the cable tray and ladder type employed. Where the cable ladder trays surfaces have been cut or damaged during installation, they must be repaired by removing rough edges and coating as per WSA 201 and Sydney Water's Supplement or SWC's FRP specification.

Galvanised steel cable ladder trays must be hot dipped galvanised after manufacture 2.0 mm steel. All supports, fittings, brackets, bolts, nuts and washers must also be hot dipped galvanised. Cut or damage to the exposed metal must 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 must be heavy duty marine grade aluminium with continuous ventilated base.

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

Where used stainless steel must be grade 316. Cuts or damage must 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 must be made of the same material and have the same finish. If interfaces of dissimilar metals occur, they must be insulated or fully and effectively coated to prevent galvanic corrosion as per SWC Technical Specification - Mechanical.

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 must be fixed by clamps, fixed every 600 mm, 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 must be equipotential bonded for protective earthing purposes as per AS 3000. Tray systems must be mechanically and electrically continuous using tees, bends, ramps and fly-overs.

E16 Works tests and inspection

E16.1 Factory acceptance testing - HV equipment

HV equipment must be subjected to factory tests as specified in the equipment specification listed in Clause 5.

E16.2 Factory acceptance testing - LV equipment

The switchgear must 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 must 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
8. Measurement of partial discharges of cts and vts
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 must 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 must be secondary injection testing.

Primary injection tests must be performed on each metering current transformer and its associated meter(s) or transducer(s). As a minimum, these tests must 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 must be made available for SWC to attend.

E16.3 Site test

Site test must be performed and recorded on test sheets to ensure equipment integrity and correct site wiring.

As a minimum, tests must 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 FAT)
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 must be carried out using NATA certified instruments. These instruments must be capable of printing out the readings and the results must be submitted as instrument printouts and not as read out.

E17 Documentation

All documentation listed in this Section must be submitted as two hardcopies and one electronic copy.

E17.1 Design calculations

Design calculations must be reviewed and verified by a suitably competent person as stipulated in the SWC 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 415 V 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 electronic files must be submitted to SWC.

E17.4 O&M Manuals

The equipment manuals must be containing sufficient information for the operation, maintenance and fault finding. Supplier details and technical support contacts must be included.

E17.5 Work-as-constructed (WAC) Drawings

WAC drawings must be submitted with an index of all drawings. The drawing files must be in both AutoCAD and PDF format.

The following drawings as a minimum, must be submitted as a part of the WAC 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 (SLDs) 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
21. Lightning protection details and 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 must be submitted.

Document ownership

Role	Title
Group	Liveable City Solutions - Integrated Systems Planning
Owner	Manager of Urban Design and Engineering
Author	Lead Engineer Electrical
BMIS Number	CPDMS0022

Revision log

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1	Ken Tse	21 May 2008	Peter Gillman	2 June 2008
2	Ken Tse/ Colin Ho	31 March 2010	Peter Gillman	31 May 2010
3	Ken Tse	30 June 2011	Peter Gillman	21 September 2011
4	Ketha Ketharanathan	17 October 2012	Peter Gilman	17 October 2012
5	John Wong	1 October 2013	Peter Gilman	2 October 2013
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8	Ketha Ketharanathan / John Wong	22 December 2015	Ken Wiggins	22 December 2015
9	Robert Lau / Paul Zhou	30 May 2017	Ken Wiggins	01 June 2017
10	Robert Lau / Paul Zhou / Simon Ross / Scott Tillman	25 June 2018	Ken Wiggins	25 June 2018
11	Robert Lau / Paul Zhou	13 August 2019	Ken Wiggins	29 August 2019
12	Paul Zhou	13 January 2020	Ken Wiggins	13 January 2020