Standard for Electrical Installations

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1 INTRODUCTION

1.1 Background

Shoalhaven Water has a strategic view to establish consistency for the delivery of electrical installations through the development of a suite of electrical standards and specifications so that future electrical works can be designed and constructed to derive the benefits of harmonisation across operations and project management.

1.2 Scope and Purpose

This electrical specification sets out the minimum guidelines for the design and construction of low voltage electrical works. The majority of Council's installations are supplied at low voltage.

It is intended to provide consistency in electrical design and installation requirements and through this harmonisation, allow Council to fulfil its health, safety and environmental obligations in the delivery and implementation of their electrical works.

This document is not intended to be prescriptive to the extent that it restricts design or installation choices by the electrical designer or constructor. However, any alternative design decisions shall require the prior approval of Council. Where there is a conflict between this document and statutory requirements, the later takes precedence.

1.3 Definitions and Abbreviations

Table 1: Definitions and Abbreviations

Abbreviation	Definition
A	Amperes
AC	Alternating Current
AS	Australian Standard
ASP	Accredited Service Provider
CB	Circuit Breaker
CCEW	Certificate of Compliance Electrical Work
CT	Current Transformer
DB	Distribution Board
DC	Direct Current
EE	Endeavour Energy
ELV	Extra Low Voltage
EMC	Electromagnetic Compatibility
EPL	Equipment Protection Level
FAT	Factory Acceptance Test
FDAS	Fire Detection and Alarm System
FIP	Fire Indicating Panel
HVAC	Heating, Ventilation and Air Conditioning
I/O	Input/Output
IS	Intrinsically Safe
JB	Junction Box
LCD	Liquid Crystal Display
LCS	Local Control Station
MCC	Motor Control Centre
MEN	Multiple Earth Neutral

MPD	Meter Protection Device
MSB	Main Switchboard
MLSS	Mixed Liquor Suspended Solids
PFC	Power Factor Correction
PLC	Programmable Logic Controller
PWM	Pulse Width Modulation
RCD	Residual Current Detection
RTU	Remote Terminal Unit
SAT	Site Acceptance Test
SCA	Switchgear and controlgear assembly
SCADA	Supervisory Control and Data Acquisition
SCC	Shoalhaven City Council
SiDRCD	Safety in Design Residual Current Detection
SPD SCADA	Service Protection Device Supervisory Control and Data Acquisition
SPS	Sewer Pump Station
SWC	Shoalhaven Water Council
UPS	Uninterruptible Power Supply
VSD	Variable Speed Drive
WPS	Water Pump Station
WSDOL	Wiring System (Classification) Direct Online
VVVFCCEW	Variable Voltage Variable Frequency Certificate of Compliance Electrical Work
VT	Voltage Transformer

1.4 Terminology

The following terms are used interchangeably in this document:

- Shoalhaven Water and Council
- Principal and Principal

1.5 Glossary of Definitions

Due to the complex nature of different sites, particularly for consultants, contractors and non-electrical staff, it is difficult to understand the difference amongst the types of electrical boards. The aim of these definitions is to define the differences between the types of boards found on Shoalhaven Water sites.

1.5.1 Meter Board

- A standalone board that contains the revenue electricity meter, MEN, SPD/MPDs and the main source of supply with a main breaker and a few distribution circuits. Will be either whole current for smaller sites or CT meter for larger sites where the demand is more than 80A/phase.
- If the metering is consolidated into another board like a MSB or SCA, the board will be defined by the latter rather than a meter board
- Can contain the distribution board and in this case the definition of a meter board remains
- Typically found at smaller sites and connected to a service pole

1.5.2 Main Switch Board (MSB)

- Contains the main incoming supply which distributes to the various branches of the electrical installation. Each branch feeds power to downstream distribution boards, motor control centres, SCAs and power quality correction. The MSB can also contain switchgear.
- Can include the meter board items as described under ‘Meter Board’

- Typically found in indoor switchboard rooms at large sites like water and wastewater treatment plants

1.5.3 Motor Control Centre (MCC)

- Physical groupings of more than two motor starters in one assembly
- Typically found at water and wastewater treatment plants

1.5.4 Switchgear and Control Assembly (SCA)

- Often two motor starters in one assembly, typically in a duty and duty stand-by arrangement
- In only a few situations, three motor starters for duty ,duty assist and duty standby
- Typically found at roadside pump stations or dispersed at treatment plants, can be found indoor or outdoor and is labelled as either an indoor or outdoor SCA,
- Often includes the distribution board, RTUs, PLCs and telemetry equipment.
- Often includes meter board items

1.5.5 Distribution Board (DB)

- Contains protective devices like fuses, circuit breakers, ground leakage protection, terminal strips for lighting and power circuits
- In a few situations also contains sub-metering, contactors, relays and timers for lighting
- Typically found at all sites but can be contained within another board like an SCA, MSB or a meter board

1.5.6 Power Quality Correction Board

- Its function is to eliminate penalties for producing and injecting poor reactive energy or harmonics onto EE network and also protects sensitive Shoalhaven Water equipment
- The board is typically stand alone and contains either power factor correction (PFC) units for reducing the reactive power or harmonic filters to filter unwanted superimposed additional frequencies to the fundamental frequency
- Sites can contain both PFC and harmonic filters
- Typically found at most large sites due to harmonics-generating equipment at those sites

1.5.7 Uninterruptible Power Supply (UPS)

- This is typically stand alone and configured in banks determined by the size required and contains rectifier, batteries, inverter and bypass switch
- Self-activates in the event of power disruption
- Typically found in the following situations:
    - Stand-by – To back up low power devices using a DC/AC inverter output and is then the primary source of power until electronic devices can be shutdown safely or an emergency source takes over (e.g. generator)
    - Line-interactive – Uses a variable voltage transformer to add or subtract the transformer's output voltage to protect against fluctuations as well as provide back-up power if there is an outage
    - Double conversion online – Same as line-interactive except a rectifier drives the DC/AC inverter, even when it is powered by normal AC current and protects against most power disturbances

1.5.8 Local Control Station (LCS)

- Comprises the control devices for equipment, typically made up of stop/start pushbuttons and selector switches

1.5.9 Junction Box (JB)

- Typically used to marshal and organise field wiring to facilitate fault-finding

2 STANDARDS, CODES AND REGULATIONS

2.1 List of Standards, Codes and Regulations

All electrical work performed and electrical equipment supplied and installed under this Contract shall comply in every respect with the relevant by-laws, regulations, Standards and Codes.

Where a Standard, Code or Regulation is referenced, by implication, this shall be the current version of the said document.

Proof of compliance with a Standard or specified tests may be required. Where requested, such proof shall comprise a test certificate from an independent Testing Authority.

Where electrical or instrumentation equipment needs to be supplied and installed in potential explosive atmospheres due to the presence of concentration of gases, vapours or combustible dust (Hazardous Areas), this equipment, and its installation, shall be certified to IEC Ex or AUS Ex certification.

Where a Standard Specification requires reference to another Standard Specification and that Standard has been amended, replaced or superseded or withdrawn, the reference shall be taken to apply to the replacement of that Standard. If necessary, the Standards Association of Australia shall be consulted for a determination of the appropriate replacement Standard.

2.2 Precedence and Contradictions

Where conflict arises between the current reference Standards, Codes or Regulations and this Standard, the precedence shall be as follows:

- AS/NZS 3000 Wiring Rules
- Endeavour Energy Supply Authority Standards
- NSW Service and Installation Rules and
- This Standard

2.3 Accredited Service Provider Works

Where Levels 3, 2, or 1 works are required under the scope of the Contract to which this Standard is applied, the Contractor shall be, or shall engage as a sub-Contractor, a Level 3, 2, or 1 ASP (as applicable to the works) registered with the Department of Fair Trading and approved by the relevant Supply Authority.

The ASP's works shall be in accordance with the relevant Supply Authority's certified drawings and to the relevant Supply Authority's standards.

3 OPERATING AND DESIGN CONDITIONS

3.1 Environmental Conditions

3.1.1 General

All equipment and materials shall be designed and constructed for service under the meteorological and site conditions prevalent in the catchment areas of Shoalhaven City Council.

3.1.2 Equipment Ratings

Equipment shall be rated for continuous operation within the range of ambient conditions as follows, unless otherwise specified:

- Temperature: 0°C to 40°C (indoor)
  0°C to 50°C (outdoor)
- Relative Humidity: 10% to 95%

3.1.3 Equipment Protection

Equipment protection considerations fall under two categories:

- Ingress Protection (IP) as defined in AS/NZS 60529 for protection of the equipment from different forms of environmental conditions and
- Equipment Protection Level (EPL) as defined in AS/NZS 60079 for determining and selecting devices for their suitability to be installed in specific zones of Hazardous Areas.

All equipment shall be selected to suit the IP or EPL (if required) classification for their use.

3.2 Electrical Supply

3.2.1 General

Endeavour Energy is the Supply Authority in Council's catchment area.

The majority of Council's electrical infrastructure is supplied at low voltage. Where ASP works are required, suitable parties shall be engaged to perform these works (refer Clause 2.3)

3.3 General Design Philosophy

3.2.2 Design calculations

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

1. Cable sizing
2. Transformer sizing
3. Generator sizing
4. Battery sizing
5. Short circuit current calculation up to 400V for 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

12. Maximum Demand calculations
13. Lightning Risk Assessment (to AS1786)
14. Hazardous Area classification, assessments and calculations including IS cable and barrier calculations (if required)

3.2.3 System Study Reports

System study reports shall be provided for acceptance as part of the project handover. The final report shall 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 shall be reviewed and finalised at the concept design stage to acquire the baseline of the system and provide input for the detailed design stage.
2. A proposed detailed design addressing the items identified in the initial assessment study. This shall consist of engineering designs and calculations based on the agreed engineering mitigation method from the initial assessment study. This part shall be reviewed and finalised at the detailed design stage.
3. The final results demonstrating the design and modifications meet the technical requirements. This part shall be finalised during the commissioning of the installations.

The requirements for system study reports applies to the 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)
8. Hazardous Area Zoning and Classification

3.2.4 Fault Levels

The electrical designer shall be responsible for determining the fault levels to be applied to the design of the electrical supply to Council's assets (pump stations, treatment plants, depots and other buildings or installations), and for coordinating and liaising with the Supply Authority in determining the fault levels.

Typically, the expected fault level at Council's standard pump stations is 30 kA, while main switchgear and controlgear assemblies in installations such as treatment plants are designed to withstand 50 kA for 1 second.

3.2.5 Power Factor Correction

The electrical systems for Council's plants shall be designed to ensure that the power factor for the whole installation meets or betters 0.95 lagging during plant normal operations.

The design of the power factor correction equipment shall comply with the requirements of the Supply Authority and shall be considered in a holistic context as follows:

- Automatic adjusting versus load-based or fixed compensation capacitor banks to suit the application regarding operability, maintainability and value and

- The total network environment of the plant with regarding implications of harmonics-producing drives, harmonics emissions and catering for potential changes in plant loading due to plant upgrades or re-configuration.

3.2.6 Management of Harmonics Issues

Electrical installations for Council's plants shall be designed to ensure that any distorting or fluctuating loads do not result in harmonics emissions and voltage regulation issues that are unacceptable to both internal plant and Supply Authority networks.

Electrical installations shall therefore comply with, but not limited to the following:

- AS/NZS 61000 Parts 3.2, 3.4 and 3.12 pertaining to limits for harmonic current emissions
- AS/NZS 61000 Parts 3.3 and 3.5 pertaining to limitation of voltage fluctuations and flicker
- AS/NZS 61000 Parts 3.6 and 3.7 pertaining to assessment of emission limits for the connection of distorting and fluctuating loads to MV, HV and EHV power systems
- Agreed limits with Endeavour Energy (as applicable to the project)
- Agreed acceptance criteria/process with Endeavour Energy (as applicable to the project) for the harmonics mitigation solutions and
- Agreed approach and assessment process with Shoalhaven Water to consider and account for pre-existing power quality conditions at the site in question.

3.2.7 Safety in Design

The design of electrical infrastructure in all Council plants or assets shall duly consider the purpose, safe operation and required level of reliability, operability and maintainability for the personnel and plant. The design process shall incorporate key principles of risk assessment, safety-in-design, failure mode analysis, and availability and reliability concepts covering the design life-cycle areas of:

- Investigation and Design
- Setup, construction and commissioning
- Operation
- Maintenance and
- Disposal

In addition to the requirements of undertaking HAZOP and CHAIR assessments, a Safety in Design Risk Assessment shall also form part of the requirements in all design phases and shall be facilitated via interactive workshops between the electrical designer, Shoalhaven Water and other invested third parties.

3.2.8 Drive Isolation

Council's philosophy for drive isolation is to isolate each drive at its main circuit breaker/isolator at the source of its power supply, that is, at the MSB, MCC, SCA or DB to Council's electrical isolation procedures. Visual indicator lights shall be provided to indicate status of all phases.

3.2.9 Emergency Stops

Emergency stops for drives and other equipment or processes shall, as a minimum, comply with the requirements of AS4024 and current Health, Safety and Environment statutory requirements.

A risk assessment shall be undertaken during the design process with operations and maintenance input from Council so that elimination of risks is considered.

Emergency stops shall be only used for their intended purpose which is to stop the relevant equipment upon an abnormal or emergency situation and shall not be used for the purpose of electrically isolating equipment for maintenance purposes.

3.2.10 Hazardous Areas

Where hazardous areas (including confined spaces) cannot be avoided in the design of plants and process, the electrical installation shall be suitable for the respective classification of hazardous areas. Identification of hazardous area shall form part of the SiD assessment.

3.2.11 Manual Plant Operation

The plant shall be capable of being safely operated using field push buttons whenever there is any failure of automatic operation.

3.3 Materials and Workmanship

All materials used in the equipment supplied under this Standard shall be new and suitable for the service required.

All electrical insulating materials shall be of high dielectric strength and shall comply with the requirements as specified in the relevant Standards.

Equipment models shall be current unless otherwise specified and/or approved by Council.

The entire electrical installation carried out under this Standard shall be carried out in a professional workmanlike manner, in accordance with the best industry practice.

3.4 Preferred and Nominated Equipment Suppliers

The term “preferred” as applied in this Specification implies that the “family” or brand of products is known or familiar to Council but does not necessarily imply restrictions to selection of other brands.

The term “nominated” as applied in this Specification implies that where possible, the “family” or brand of products should be selected to ensure continued harmonisation and interfacing with key equipment already installed in the plant.

Alternative brands and models of nominated equipment shall be subject to Council’s approval. Where such alternative brands and models are offered and accepted by Council, the Contractor will be required to warrant the substituted brand and model and may be required to alter standard design drawings.

The following table list nominated and preferred equipment suppliers respectively for the electrical, instrumentation and control equipment.

Table 2: Preferred and Nominated Equipment Supplies

Item	Description	Preferred Brand/Product
1	Miscellaneous Equipment	
1.1	Actuator Valves	- Rotork - Bray
1.2	Variable Speed Drives and Soft Starters	- Danfoss - Vacon - ABB

1.3	Dosing Pumps	- Prominent - Grundfos - Iwaki
1.4	Pneumatic Position Control Actuator Valves	- Rotork - Tyco AVID - Bray
1.5	Chlorinators	- Evoqua - Wallace and Tiernan
1.6	Data Compressor	- 37 South/Point Change
2	Instruments	
2.1	Hydrostatic Level Control	- Vega - Endress & Hauser FMX21 water pilot
2.2	Ultrasonic Level Control	- Vega - Endress + Hauser
2.3	Signal Isolator	- Omniflex - APCS - Mann Industries
2.4	pH Meter	- Thermo Scientific - Hach
2.5	Pressure Switch	- IFM PM/PL series - Wika PSD - Siemens - Vega
2.6	Flow Switches	- IFM Model –SA4300 - Wika FSD
2.7	Float Switches	- Flygt
2.8	DO Meters and DO Analysers	- Thermo Scientific - Royce - Endress with HART communication - HACH with HART
2.9	Electromagnetic Flow Meters	- Siemens - ABB - Krohne
2.10	Battery-powered Flow Meters	- SIEMENS Mag 6000/8000
2.11	Chlorine Analysers	- Prominent Dulcometer - Kuntze - Chemitec
2.12	Pressure Gauges – Bourdon style	- Any
2.13	ORP Monitoring	- Royce
2.14	MLSS Analysers	- Endress with HART communication - HACH with HART
2.15	Radar Level Sensor	- Vega
3	SCA Devices and Equipment	
3.1	Contactors	- Sprecher & Schuh - Schneider

3.2	Relays	- Finder (with LED) - Omron (with LED)
3.3	Miniature Circuit Breakers	- Clipsal. - Merlin Gerin. - NHP Din-T Miniature Circuit Breakers - Schneider
3.4	Push Buttons/Switches/Mimic Lights	- Schneider - Sprecher & Schuh
3.5	Moulded Case Circuit Breaker	- Terasaki Tembreak - Merlin Gerin - Schneider
3.6	Ammeters, Voltmeters, Hour run meters	- Crompton - NHP - IME
3.7	Main Switch Isolator	- NHP Socomec - Schneider - Terasaki - Merlin Gerin
3.8	Ammeters, Voltmeters, kW.hr meters	- NHP - IME - Crompton
4	PLC and SCADA equipment	
4.1	PLC	- Omron - Allen Bradley
4.2	RTUs	- Schneider 334E
4.3	Radios	- Trio/Schneider QR Series, J series
4.4	Antenna Cable	- RFI – RG213 (50Ω coax)
4.5	SCADA Software	- Schneider ClearSCADA
4.6	Panel Mount Serial Input Indicator	- IQ 230 SE Magelis XBT
4.7	Touchscreen/HMI – 10” standard preferred	- Schneider - Omron
5	Power Supplies	
5.1	DC UPS Power Supplies	- Phoenix QUINT/UPS/12DC/5/24DC/10
5.2	24v Power Supplies	- Omron S8VK-24024 - Phoenix QUINT
5.3	Power Filters, Surge Arrestors, Lightning Arrestors	- Novaris - Critec
5.4	UPS 240 VAC	- Victron Multiplus with Venus GX network connectivity - Power Shield with Networked Switched - APC
5.5	Auxiliary Power connection plugs and sockets (greater than 50 Amps)	- DS9 150A Marechal Inlet with cap - DS9 150A Marechal Outlet
5.6	Auxiliary Power connection plugs and sockets (less than 50 Amps)	- Clipsal 50A 5-pin 56AI550

5.7	Batteries	- Valen - Panasonic - Century
6	Lighting	
6.1	Well Luminaires	- LED Type
6.2	Emergency/Exit Lights	- Bardic with Sentinel Auto test
6.3	Spitfire Emergency Lights	- Bardic with Sentinel Auto test
6.4	Security/access control system	- Concept - Integrity

4 BUILDINGS

4.1 General Requirements

This section of this Standard shall be read in conjunction with the scope and civil works requirements of the project this Standard is applied.

In providing the electrical works for the project where such works will be installed in electrical switchrooms, the Contractor shall coordinate and liaise with the Principal and other service providers as applicable to:

- Consider any access constraints to the site to ensure that major items such as SCAs and MCCs can be delivered and installed in their final location
- Ensure civil and other building requirements for SCAs, MCCs and other major electrical equipment have been duly considered and included in the building/room design including but not limited to door head heights, cable penetrations, underfloor access, drainage of pits, etc; and
- Ensure the design and installation of electrical building services will be properly incorporated by the party providing the civil/building works.

This section is therefore in two sub-sections (Section 4.2 Electrical Switchrooms and Section 4.3 Building Services). The purpose of each sub-section is described as follows:

1. Concept for Electrical Switchroom design that will typically fall under a civil works/building scope. This shall act as a reference for the electrical services provider in considering placement of SCAs and cable entries and
2. Building Services requirements (egress, safety, emergency lighting, fire detection, building security). These are performance and standard specifications for the electrical works for buildings.

4.2 Electrical Switchrooms

4.2.1 Infinite Access Floor

Electrical switchrooms in Council's plants and facilities will typically have underfloor access. Where such floors are constructed (by others) to comprise a modular panel arrangement with an under-structure:

- The under-structure shall be connected by the electrical contractor to the site electrical earth
- The installation of the floor panels shall be coordinated with the installation of the SCA frames as SCA's shall not be directly on the infinite access floor

Cables in underfloor space shall be run on hot-dipped galvanised cable ladders. All cable ladders shall be electrically contiguous and connected to the site electrical earth.

4.2.2 Drainage of Electrical Switchrooms

The electrical switchroom sub-floor will be designed to slope toward a drainage sump or stormwater drainage.

4.3 Building Services

4.3.1 Lighting

General Requirements

All light fittings for buildings shall be procured from a reputable supplier and manufactured in accordance with AS/NZS 60598.1 and AS/NZS 3100.

Interior and workplace lighting shall be designed to meet the requirements of AS/NZS 1680 Part 1.

All luminaires shall be complete with facility for earthing. All luminaire accessories shall be positioned so that they are readily accessible.

Photometric data, copies of Statutory Approvals and Supply Authority letters shall be supplied to the Principal if requested.

The metal work of light fittings exposed to dust, water or weather shall be protected against corrosion and correctly IP rated.

Where luminaires are mounted on a fire rated ceiling or fire rated walls, the integrity of the ceiling or wall shall be maintained.

Consideration shall be given to Obtrusive Lighting "AS/NZS 4282" and mitigation methods if the requirements in this standard cannot be met (i.e., light shields or nominating asymmetrical light fittings).

For floodlighting mounted on steel poles, the poles are to be a minimum galvanised steel. Engineered Certified geotechnical drawings of the site as well as floodlight technical specifications are to be provided to the pole manufacturer as part of obtaining correctly engineered footings and pole selection. The pole is to have an access door for a compartment containing drivers and protection equipment, assessable from ground level or potentially a small ladder for poles with multiple drivers.

The baseplate of the poles shall be raised a minimum of 150mm of ground to allow for water shedding with a grout neatly compacted between the ground and the baseplate and a weep hole for water to exit the interior of the pole.

Poles are to be structurally adequate and certified in accordance with Australian design standards and specified conditions. Refer to Table 3.

Table 3 Standards Associated with Lighting Structures

Wind Loading	AS/NZS 1170.2 Structural Design Actions Part 2: Wind Actions • Wind Load Region = A • V500 regional Wind Speed = 45m/s • Terrain category = 2 • Topographic Multiplier = 1.0
Structural Design:	AS/NZS 4100 Steel Structures AS/NZS 4600 Cold Formed Steel Structures AS/NZS 1554.1 Structural Steel Welding, Part 1: Welding of Structures AS/NZS 4680 Hot-dip Galvanised (zinc) Coatings on fabricated Ferrous Articles AS\NZS 3600 Concrete Structures AS/NZS 2159 Piling – Design & Installation

Description of Lighting Operation and Controls

Lighting shall be controlled by the following methods as appropriate to suit the function of the plant areas:

- Manual switching
- Timer
- Photo-electric switching
- Remote authorisation

Photo Electric Switch

A photo electric switch shall be used for control of external lighting with the following features:

1. Light sensitive controller (P.E. Cell) to turn switch on and/or off at dusk and/or daybreak respectively and incorporating a time delay circuit, so that it is not affected by sudden or brief change in light level caused by intermittent cloud cover, reflections, vehicular lights or lightning
2. IP56 impact resistant housing, with non-corroding and non-conductive cover, suitable for permanent fixing direct on a wall (not plug in type)
3. Final position to be determined on site

4.3.2 Emergency and Exit Signs

4.3.2.1 General

The emergency lights shall comply with AS/NZS 2293 Parts 1 and 2. Electronic components to be rated for 105°C operation.

All emergency and exit signs shall be installed with a self-diagnostic feature.

All emergency and exit fittings shall be appropriately labelled and a logbook provided to the Principal.

All emergency and exit lights shall be wired from a local distribution board with an emergency lighting testing circuit as required by AS/NZS 2293.

4.3.3 General Power and Socket Outlets

Three Phase Socket Outlets

For three phase socket outlets, provide a five round pin arrangement with the earth pin at the 6 o'clock position, the neutral pin in the centre, and the Red, White and Blue phases in a clockwise sequence when viewed from the front of the socket.

Three phase socket outlets shall comprise an approved, industrial heavy duty, surface mounted combination switch socket IP56 assembly of impact resistant plastic, with flap lid and complete with five pin plug top and screw ring for holding plug top in position.

4.3.4 Fire Detection and Alarm

General

This section of the standard sets out the requirements for the provision of an automatic Fire Detection and Alarm System (FDAS) for the facility where such a system is required.

A fire detection and alarm system (FDAS) shall be provided in accordance with the Building Code of Australia (BCA) to suit the building classification. Building types shall include but be limited to the following:

- Administration / office / amenities buildings
- Chlorination building, Blower rooms and Chemical Dosing buildings
- Substation and switchroom buildings
- Standalone pump station buildings and/or switchrooms
- Other ancillary buildings within treatment plants

In the case of a large sites or facilities that have several buildings, the FDAS shall be distributed to a variety of building types/ancillary structures with a main Fire Indicator Panel (FIP) usually located at the main administration building.

The Fire Detection and Alarm System shall comply with the relevant requirements of AS/NZS 1670 'Automatic Fire Alarm Installations' and AS/NZS 4428.1 'Automatic Fire Detection, Warning, Control and Intercom Systems – Control and Indicating Equipment – Part 1: Fire'.

The FDAS shall be designed by an accredited fire protection and alarming specialist.

4.3.5 Security and Access Control System

General

Security/access control systems shall consist of:

- System master controller
- Access controller module
- Main automatic gate controller (where applicable)
- Security CCTV system with IP cameras and networked video recorder (where applicable)
- Motion sensors and
- Numeric keypads

4.3.6 Building Evacuation Siren System

Council's plants, administration buildings may require a building evacuation siren system to facilitate the safe and efficient evacuation of personnel from the site in the event of an emergency.

The building evacuation siren system shall typically comprise the following components:

- Pull/push switch located internally adjacent to main entry door
- Siren mounted on building roof
- Strobe lights mounted on building facia

The system shall operate as follows:

- Pull front entry switch to activate siren and strobe lights
- Push front entry switch to deactivate siren and strobe lights

The building evacuation system shall be connected to the telemetry system so that such evacuation incidents can be alerted on the telemetry master station.

5 Distributed Generation

A Concept Design shall be prepared and risk assessment shall be carried out before proceeding to detailed design of power supply and control system of all process equipment.

Process equipment that is critical to plant operation shall be identified. Control and power supply to these critical processes shall be provided with adequate redundancy to ensure that plant performance standard is within operating licence requirements.

Consideration shall be given to the use of UPS and/or standby generators and how equipment behaves when power supplies fail (e.g., valve fails to an open or closed position).

Duty and standby equipment starters shall have their power supplied from separate sections of a switchboard.

Failure of any single device shall not prevent operation of more than one process equipment.

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

When multiple supplies including standby generator supplies are required for one switchboard, the design shall ensure each incoming supply switch is housed in an independent switchgear panel.

The layout and configuration shall be designed to minimise the potential risk of live work being carried out.

Noting the move toward solar generation, both the main incoming and the standby generator circuit breakers shall be mechanically interlocked as per AS/NZS 3010 so that only one of them could be ON at any time.

Performing maintenance work on the standby generator switch shall not affect the availability of at least one permanent incoming supply. If there are more than one permanent incoming supplies on the switchboard, perform maintenance work on one permanent incoming supply shall not need to use the standby generator to supply power.

5.1 Standby Generator

Consideration shall be made to provide the manual connection of a standby or a permanent generator to operate during periods when electricity distributor power is not available. The requirement of whether a temporary standby or permanent generator shall form part of the risk assessment and evaluation of critical loads and operation during the initial stages of the project as well as the SiD process.

The installation of standby or a permanent generator shall be in accordance to AS/NZS 3010.

A generator connection panel shall be provided on the outside wall of the switchroom to enable the switchboard to accept power from a mobile emergency generator. The panel shall be stainless steel with padlock facility. The panel shall be fitted with clear/colourless, flat non-conductive IP2X shielding to prevent personnel from coming in contact with live terminals.

The mobile generator set cable entry is to be through the bottom of the panel. The panel door shall be able to be closed and padlocked with the mobile generator set cable connected. The panel shall be

adequately sized to allow for cable bending radius to be accommodated. Hardstand for the generator(s) shall be provided to enable the connection of the generator(s) to the connection panel without causing a safety hazard.

5.1.1 Portable Generator Connector Sizes

Table 4: Portable Generator Connector Sizes

Current (Amps)	Connection Type
<50	Clipsal
>50 & <150	Marechal
>150	Busbar connection points

5.1.2 Standards for Generators

The Shoalhaven Water Standard for Generator Requirements is included in Appendix A.

6 MAIN SWITCHBOARD (MSB), SWITCHGEAR AND CONTROLGEAR ASSEMBLY (SCA) AND MOTOR CONTROL CENTRES (MCCs)

6.1 Design Criteria

Table 5: Treatment Plant SCAs

Design Element	Description
Construction	Free standing floor mounting front access
Method of connection to incoming supply	Bottom Entry
Method of connection to outgoing submains	Top or Bottom Entry (Outdoor SCA – bottom entry only)
Form of Separation	Site Dependant – Minimum Form 2B in accordance with the latest revision of AS/NZS 61439.1 Annex ZF
Type Test Requirement	PTTA for temperature rise
Compliance with	in accordance with the latest revision of AS/NZS 61439.1 and this specification
Ventilation	Forced flow over Motor starters and Natural flow elsewhere
Earthing system	MEN
Limiting Dimensions	Consider any building access limitations for installation of the switchboard.
Degree of protection of switchboard cabinet	IP54 indoor, minimum IP56 outdoor
Supply	400V, 3 phase, 4 wire 50 Hz alternating current
Maximum prospective fault Level	As applicable Peak Factor shall be minimum 2.2
Main Busbar Rating	As applicable
Diversity factor for load circuits	One
Doors	Dust proof, smoke sealed zinc coated sheet steel, doors shall be hinged and allow 135º swing through an arc. Doors shall require tools to be opened (thumb screws are not acceptable).
Door Hinges	Stainless steel pintle pin type hinges
Door Locks	Turnbuckle
Gland Plates	Aluminium – 6mm minimum thickness

Table 6: Pump Station Outdoor Kiosk SCAs

Design Element	Description
Construction	Free standing “kiosk”-type, front access, with appropriate sun-hood
Method of connection to incoming supply	Bottom Entry
Method of connection to outgoing submains	Bottom Entry
Form of Separation	Form 3b in accordance with the latest revision of AS/NZS 613439.1 Annex ZF *REFER ABOVE
Type Test Requirement	PTTA for temperature rise
Compliance with	in accordance with the latest revision of AS/NZS 613439.1 and this specification
Ventilation	Forced over Motor Starters and Natural everywhere else
Earthing system	MEN
Limiting Dimensions	Consider any safety, building access, site or environmental limitations for installation of the switchboard.
Degree of protection of switchboard cabinet	IP56 minimum, higher rating may be required subject to specific site and environmental conditions
Supply	400V, 3 phase, 4 wire 50 Hz alternating current
Maximum prospective fault Level	As applicable Peak Factor shall be minimum 2.2
Main Busbar Rating	As applicable
Diversity factor for load circuits:	One
Doors	doors shall be hinged and allow 135º swing through an arc. Doors shall require tools to be opened (thumb screws are not acceptable).
Escutcheon (if applicable)	Dust proof, smoke sealed 2.0 mm zinc coated sheet steel
Door Hinges	Stainless steel pintle pin type hinges
Door Locks	Padlockable Swing Handle
Gland Plates	Aluminium – 6mm minimum thickness

6.2 Layout

Equipment shall be positioned to provide safe and easy access for operation and maintenance. Consideration shall be given to the functional relationship between items of equipment in the layout of the assembly.

Telemetry and other compartments that can be accessed by non-electrical licensed personnel shall have all low voltage wiring and associated power supplies located in a compartment accessible only by licensed electricians.

6.3 Supply Authority’s Equipment

The Contractor shall liaise with the Supply Authority regarding the installation and coordination with their upstream protection and control equipment.

Supply Authority metering shall be located in a separate compartment within the panel to avoid meter readers accessing other compartments unnecessarily.

6.4 Earthing

The main earth bar and the earth bar or cable connecting metal parts of the SCA, such as the frames of the air-break circuit breakers, fuse switches etc. to the main earth bar, shall have a cross sectional area such that when the maximum earth fault current is carried for the specified time, the temperature rise shall not cause any damage. Refer to Section 3.2.2.

Earthing of components via mounting fixings is not acceptable.

All metal cases of instruments, relays, selector switches, etc, either mounted on hinged doors or front covers, shall be connected by an unbroken insulated earth wire of minimum size 2.5 mm^2 to the main earth bar. The earthing connections shall be arranged so that removal of one component shall not affect continuity of the earthing conductor associated with any other component.

6.5 Discrimination

Total and full discrimination shall be achievable between incoming supply main switch(es) and all outgoing circuit breakers on the main switchboard. Trip curves for all breakers, displayed in a manner as to demonstrate that full discrimination has been achieved shall be provided. These trip curves shall be submitted with workshop drawings for acceptance.

6.6 Temperature Rise

The temperature rise limits shall apply for an ambient temperature of 40ºC after the switchboard has been operating at full load for a minimum period of 48 hours. The temperature rise limits shall comply with Table 2 – Temperature Rise Limits in accordance with the latest revision of AS/NZS 613439.1 and shall be such that:

1. All equipment operating temperatures shall be according to manufacturers' stated values taking into consideration the temperature in the assembly
2. The above temperature rise limit shall be applicable to all built in components of the assembly as defined in Table 2 in accordance with the latest revision of AS/NZS 613439.1
3. A temperature rise of 70ºC shall apply to all insulated outgoing and incoming terminals for PVC cables with all the external conductors connected, and in service (i.e. connected and operating at continuous duty full load) and
4. The outgoing cabling includes fire rated cables which can operate at a temperature exceeding the abovementioned 70ºC temperature rise for PVC cables. The outgoing functional unit's busbars with such fire rated cables shall include adequate, naturally ventilated copper bus heat sinks (etc.) in the cable zone adjacent to the outgoing functional units to prevent the temperature exceeding a 70ºC rise at the point where the busbars of the outgoing functional units penetrate into the cable zone and within the functional units.

No part of any switchboard, or piece of equipment installed in a switchboard, shall reach a temperature which will be detrimental to itself or any part of the switchboard and/or cause it to operate incorrectly due to excessive temperature conditions. For example, this applies to tripping of circuit breakers below their trip setting, operation of electronic/microprocessor-based components outside temperature limits stated by the relevant equipment manufacturer, etc.

6.7 Anti-Condensation Heaters

Anti-condensation heaters shall be installed to maintain the internal surface temperature above the dew point temperature.

The selection of the anti-condensation heater shall be determined by the amount of temperature that a switchboard will naturally dissipate when there is a temperature difference between the internal part of the switchboard and the environment.

6.8 Cabinet Construction

The SCA shall be minimum 2 mm thick zinc-coated sheet steel for indoor installations, and minimum 1.6 mm thick grade 316 stainless steel or 2 mm thick marine grade aluminium for outdoor installations, except where specified otherwise, with all joints continuously welded. The following additional construction requirements apply:

1. The cabinet shall include trim, door, lock, hinges, circuit schedule, switchgear and all wiring
2. The cabinet shall be of the totally enclosed, metal-clad type using folded sections and/or angle iron bracing where necessary for stiffeners and all joints welded with continuous seam welds. Grind all welds flush
3. Thoroughly rub down after fabrication and coat with etching type, rust-inhibiting primer and then carefully fill and paint as detailed in this Standard
4. Finished surfaces shall show no weld marks or other imperfections. Rectify any damages to finished surfaces caused in the factory, during transportation and installation
5. Doors to all sub distribution boards shall be fitted using chrome plated pintle pin type hinges which allow the door to swing through a minimum arc of 135 degrees. Access to the wiring and removal of escutcheon plates shall be made possible without removing doors from the cabinet
6. Stiffen doors and escutcheon plates in an approved manner to prevent distortion and fit with approved chrome plated handles with locks
7. Use three-point latching bars of appropriate cross sections and provide adequate guides to prevent bars from distortion when latching or unlatching
8. The escutcheon panels shall be removable and shall have “D” type chromed lifting handles mounted on each side of panel
9. All escutcheon panels fixing hardware shall be minimum M6 studs chromed acorn (dome) nuts
10. All escutcheon panels, access panels, doors, etc. shall be provided with returned edges and neoprene or soft rubber sealing strips to give a degree of protection to IP54 for indoor switchboards and minimum IP56 for outdoor switchboards. Foam plastic strips are not permitted.
11. The sealing strip shall be mounted and glued into a channel section, which has been formed by the return edge and an angle section spot welded to the panel or door, etc.
12. The SCA shall be arranged for front connection of wiring. Provision shall be made for neat fitting dead front escutcheon plates over all circuit breakers and fuses to conceal all wiring.
13. Wiring reticulated to door mounted equipment shall be bunched and looped into the cubicle on the hinged side of the doors with adequate slack to allow the door to swing through a minimum arc of 135 degrees
14. All ferrous nuts, bolts, washers, etc. used inside the switchboard shall be chrome plated steel
15. All nuts and fixing screws visible from the outside of the cubicle shall be chrome plated. The only fixing screws visible on the outside of the cubicles shall be those used for securing escutcheon panels and labels.
16. The main switchboard shall be provided with removable undrilled non-magnetic gland plates for cables entry/exit. These cables shall be fitted with cable glands to maintain the IP rating of the switchboard.

17. Doors shall be dust proof, smoke sealed, hinged and latched to switchboard fixed casing
18. Escutcheons shall be hinged or removable and independent from switchboard door
19. Care shall be exercised to avoid contact between metals of widely dissimilar electrode potential to minimise possible electrolytic corrosion arising there from. In particular, copper or brass shall not be placed where it can be contacted with aluminium.
20. The main switchboard shall be floor mounted on a full perimeter hot dipped galvanised steel channel base. The minimum dimensions of the channel base shall be 75 mm high, 40 mm wide, and 6 mm thick and
21. The colours of the switchboards shall comply with AS2700. They shall be:
    - Indoor switchboards: X15 Orange
    - Weatherproof switchboards: G54 Mist Green
    - Removable equipment panels (e.g. backing panels, mounting panels, eschutcheons): N14 white

6.9 Type Test Certificates

6.9.1 Switchboard Manufacturer

The switchboard manufacturer shall be the responsible for the issue of type test certificates for the switchboard.

6.9.2 Type Tests Proof of Performance

All switchboards shall be partially type tested assemblies as defined in accordance with the latest revision of AS/NZS 613439.1.

Prior to final switchboard manufacture, the Contractor shall submit a clearly marked up set of drawings of each type of switchboard design, which has been assembled from relevant type tested assemblies and obtain approval from the Principal.

Each drawing shall bear cross reference to the relevant Type Test Certificate and Report.

6.10 Switchboard Components

Switchboards are to be built in accordance with AS 613439.

6.10.1 Busbars Size and Ratings

Busbars sizes in relation to ratings shall be in accordance with the latest revision of AS/NZS 3000 and AS 613439 assuming the switchboard is of magnetic material, located indoors in a well-ventilated room.. Certificates of compliance with the test requirements in accordance with the latest revision of AS/NZS 63439.1 from an independent authority shall be provided by the Contractor.

6.10.2 Busbar Supports

Busbar joints and supports shall be made using minimum M10 plated steel precision bolts in accordance with the latest revision of AS/NZS 1110.1 with minimum strength grade of 8:8. One plated steel full flat washer on each side of the joint and one plated steel full nut torque tightened to the manufacturer's recommendation.

The busbar and terminals shall be insulated with a flame-retardant material. All busbar connection and extension ends shall be pre-drilled for installation of future switchgear and extensions.

6.10.3 Insulation

Busbars shall be encapsulated with heavy duty coloured PVC and marked in their phase colours.

Busbars joints shall be sleeved with heat shrink PVC and marked in their phase colours.

All insulating material shall withstand maximum busbar temperature without any deterioration.

6.10.4 Earthing

- The multiple earthed neutral (MEN) system shall be used and all related requirements in accordance with the latest revision of AS/NZS 3000 Contractor shall request site specific arrangement of MEN from Principal.
- An earth cable shall be bonded to every individual item of electrical equipment so that the earthing is electrically continuous
- The earth bar shall run the full length of each switchboard, behind the SCA, and provision for extension of the earth bar shall be made at each end when additional cubicles are added
- Earth pits are to be used into the ground in a location accessible for testing. These pits shall be installed with a plastic cover, with finished surface level equal to surrounding ground to avoid a trip hazard.
- The location for the mounting of the earth stake shall be submitted to the Principal for approval.

6.10.5 Switchboard Conductors

- PVC and PVC/PVC cables shall be type V75, manufactured in accordance with AS/NZS 1125.
- Colours used shall be red, white and blue for phase wiring, black for neutral, green/yellow for earth wires and violet for control wires
- Control cables shall be multicore PVC insulated and sheathed 0.6/1 kV underground type with stranded copper conductors having a cross sectional area of not less than 1.5 mm^2. Each conductor shall be numbered in accordance with the latest revision of AS/NZS 5000.1.
- Instrument signal cables shall be insulated and sheathed electronic instrument type with stranded copper conductors having a cross-sectional area of not less than 0.5 mm2. Each pair of conductors shall be twisted to reduce inductively coupled magnetic noise and each cable shall have individually and overall screened pairs to reduce capacity coupled static noise. Sheath colour shall be black. Earthing of the screen shall be at the control panel only and shall be achieved by connecting the screen to the instrument earth busbar, insulated from protective earth.
- All cables throughout the installation shall be correctly segregated in accordance with the requirements for segregation of different voltage levels set out in AS/NZS 3000.

6.10.6 Main Switch

Main switches shall be interlocked with switchboard escutcheon/door to prevent opening in the “ON” position.

Adequate labelling shall be provided to notify any person of the interlock between the escutcheons and main switch.

6.10.7 Meters and Metering Equipment

Meters

All indicating meters cases shall comply with AS/NZS 60529 to at least IP54.

Metering compartments are to be separate from the Switchboards.

Indicating Instruments

All indicating instruments cases shall be dustproof and comply with AS/NZS 60529 to at least IP56.

Digital Power Monitors

The digital power analyser monitors shall provide the following information locally and shall include facility to be connected via the SCADA system via 4 to 20 mA signal, serial or industrial Ethernet interface, where applicable (the latter being preferred):

- Voltage: phase to phase, phase to neutral;
- Current: three phases and neutral currents;
- Power: active reactive and apparent power;
- Energy: cumulative kWh;
- Frequency; and
- Power factor.

Displays shall be suitably scaled such that under normal operation conditions the least significant digit shall be clearly legible.

6.10.8 Selector Switches

Switches shall be supplied with a complete escutcheon plate engraved by the manufacturer.

6.10.9 Phase Failure Relay

The phase failure relay shall monitor each phase of the incoming supply for undervoltage and shall provide an open contact output upon any of the phases going outside the pre-set range. The relay output shall have a programmable delay of between 0.1 and 10 seconds. The relay shall be rated at 415 V, 20 A.

A 2nd Phase failure relay shall monitor each phase of the Load side of Main/Generator Switch for undervoltage and shall provide an open contact output upon any of the phases going outside the pre-set range. The relay output shall have a programmable delay of between 0.1 and 10 seconds. The relay shall be rated at 415 V, 20 A.

6.10.10 Fuses

High rupturing capacity fuses, in accordance with the latest revision of AS/NZS 60269.1, shall be installed where indicated.

Spare fuses shall be provided to 10% of the number of each of the different fuses used in this installation, or four, whichever is the greater, to be located in a supplied spare parts cabinet.

6.10.11 Residual Current Devices (RCD)

Residual Current Devices to be installed in accordance with the latest revision of AS 3000

6.10.12 Contactors

Contactors shall be in accordance with the latest revision of AS/NZS 60947.4.1 – Low-voltage switchgear and controlgear – Contactors and motor-starters – Electromechanical contactors and motor-starters.

One N/O spare auxiliary contact and one N/C spare auxiliary contact. Spare auxiliary contacts may be supplied if endorsed by the Principal.

full Load.

6.10.13 Indicator Lights

All indicator lights shall be LED type.

Standard

Indicator lights shall be in accordance with the latest revision of AS/NZS 60947.5.1 – Low-voltage switchgear and controlgear – Control circuit devices and switching elements – Electromechanical control circuit devices.

Degree of protection

LED Indicator lights shall have an ingress protection rating of IP54.

LED indicators Technical Requirements

The following technical specifications apply:

- Power Supply shall be 10 to 30 V DC as necessary
- Housed in corrosion-resistant bezel
- Press-to-test
- Compartments/subsections with < 5 indicating lights: Provide each indicating light with a fitted integral press-to-test lamp actuator and
- Compartments/subsections with > 5 indicating lights: Provide a common press-to-test lamp push-button.

Colours of Indicator Lights

- Stopped (or valve closed) Unlit
- Running (or valve open) Green
- Fault Red
- Unavailable Yellow

6.10.14 Pushbuttons

Push Buttons shall be of the oil tight type with minimum rated operational current of 4 A, 240 VAC. Size classification shall be uniformly D22.

Each pushbutton shall be provided with a legend plate indicating its function. All reset buttons are to be on the same panel as the control switches.

Colours of Pushbuttons

- Stop (or valve closed) Red
- Start (or valve open) Green
- Reset Black

6.10.15 Emergency Stop Pushbuttons

In the case of latched ‘STOP’ or ‘EMERGENCY STOP’ push buttons, instructions for releasing the latch shall be included either on the legend plate or on the face of the button.

Emergency Stop pushbuttons shall be wired to a Pilz-type safety relay in accordance with the requirements of AS/NZS 1604.

Push buttons and emergency stop buttons where located outdoors, shall be contained within a corrosion proof metal housing having an IP56 classification to AS/NZS 60529.

6.10.16 Automatic Transfer Switch

The automatic transfer switch arrangement shall comprise air circuit breakers on the mains and generator supplies, and a microprocessor-based controller.

The ATS controller shall be complete with auxiliaries control plate.

The ATS shall monitor all phases of the mains power and activate the diesel generator when the mains voltage or frequency reaches an unacceptable level.

Automatic controls shall signal the generator set to start upon a signal from the normal source sensors. A time delay before load transfer from normal to emergency source, adjustable from 0 to 120 seconds shall be provided.

Controls shall signal the generator set to stop after a time delay upon return of the normal source. A time delay before load transfer from emergency to normal source, adjustable from 0 to 30 minutes shall be provided.

Power for the transfer shall be from the source to which the load is being transferred.

A set of terminals shall be provided to allow connection to the plant SCADA system to monitor which supply is selected (e.g., mains or back-up generator).

6.11 Infra-Red Scanning

During the FAT stage of the project, all busbars, switchgear, connections and any other equipment within each switchboard shall be checked with an infra-red scanner and the temperatures recorded. All temperatures shall be recorded in degrees Celsius on an appropriate diagram of the switchboard. The results shall be included as evidence in the ITP documentation.

Any sections of the switchboard that produce abnormal temperature readings shall be disassembled, checked, reassembled, and then tested by the Contractor at no variation in price.

6.12 Switchboard Labelling

6.12.1 General

Indoor switchboard labels shall be engraved Traffolyte type and shall be screw fixed to switchboard external surfaces (doors, panels etc.) and internal escutcheons. Switchboard labelling shall be as per AS/NZS3000 requirements.

All labels shall be minimum 4 mm black letters on a white background and be in accordance with the requirements in the latest revision of AS/NZS 3000. In addition, the labelling of terminals shall be visible from the front of the switchboard with wiring installed.

6.12.2 Manufacture Name/ Designation

The new switchboard Identification number (plant number) and switchboard naming protocol shall be obtained from the Principal prior to fabrication.

6.12.3 Pole Numbering

Each circuit breaker pole space shall be numbered from top left to bottom left consecutively on each side of chassis, down vertically, commencing from number one. Each side of the chassis shall not be alternately numbered.

6.12.4 Duplication

No two circuits on any switchboard shall carry the same numerical identifier.

Prefixes to denote power or light circuits shall not be used.

6.12.5 Schedules

Circuit schedules shall be produced in MS Excel® format and an electronic copy shall be submitted to the Principal. Handwritten amendments of the schedules are not permitted.

Circuit schedules shall be laminated and placed in an A4 sized holder fixed to the switchboard panel.

6.13 Transient Protection System

6.13.1 General

Lightning and surge protection equipment shall be installed at the main switchboard and at other locations as determined by the specific design. Such equipment shall provide protection against surges and transients induced in power and control circuits by lightning or electrical switching or transients.

The Surge Diverters shall provide protection against transients caused by lightning, power network switching, standby generator switching, capacitor switching and load switching.

The surge diverters shall protect low voltage switchgear and control equipment.

The surge diverter shall be connected between each Main Switchboard active/neutral busbar and the MEN earth link.

The units shall utilise Metal Oxide Varistors individually fused or protected by an appropriately rated circuit breaker and shall incorporate a voltage free normally closed contact, providing an individual phase segment failure alarm to the external monitoring system. The surge diverter unit shall also have a local digital display, visible without removable of escutcheon indicating a percentage activation per phase and an integral alarm to indicate required maintenance.

6.13.2 Approval

Data sheets for the proposed Surge Diverters shall be submitted for approval prior to installation.

6.13.3 Surge Diverter Performance

- Lines protected 3 phases to earth at MEN point
- Operating voltage 230 V, 50 Hz
- Maximum line voltage 275 V, 50 Hz
- Protection modes Transverse and common mode
- Impulse rating:
    - Single pulse 200 kA
    - 5 pulses 40 kA
    - 10 pulses 25 kA
- Residual voltage level:

  - Category C, 10 kA 8/20 microseconds < 1000 V
  - Category D, 70 kA 8/20 microseconds < 1500 V
- MOV failure indicationIndividual LED
- MOV failure alarm changeover contacts, 24 VDC, 1 A

6.14 Motor Starting Methods

Starting method	Requirements
DOL	Less than 5kW
Electronic Soft Starter	- Speed and Torque Control only during start-up - Over 5kw or requirement to reduce starting current -
VSD	- Ongoing Speed and Torque Control beyond start-up - Further starting current reduction than a soft-starter

6.15 Motor Starter Circuits

Motor starter circuits shall be to typical industry standards, and shall interface with the plant PLC/RTU system via the following typical signals:

- Thermal overload (digital input);
- Running (digital input);
- Available (digital input);
- Fault (digital input);
- Run request (digital output);
- Soft starter fault (digital input) – for soft starters only;
- Drive fault (digital input) – for VSDs only;
- Speed (analogue input) – for VSDs only; and
- Speed setpoint (analogue output) – for VSDs only.

Fault signals shall be wired for fail safe operation, unless approved by Principal.

The final design of motor starter circuits shall be confirmed in consultation with the Principal.

7 POWER FACTOR CORRECTION

7.1 General

Power factor correction equipment (if required) including all capacitor banks and controllers shall be installed in a separate enclosure to the SCA.

Cabling between the SCA and the power factor correction unit shall be installed in accordance with AS/NZS 3000.

7.2 System Requirements

The power factor correction equipment shall meet the following parameters:

Rated Voltage	400 V
Maximum Voltage	520 V
Rated Frequency	50 Hz
Rated short circuit current	As applicable
Capacitor bank rating	As applicable
Capacitor steps	As applicable, typically at 50 kVAR, 25 kVAR, 12.5 kVAR

The power factor correction system shall be designed to correct the power factor of the plant in accordance with Supply Authority requirements, that is, better than 0.95 lagging and not more than 1.

7.3 Configuration

The power factor correction equipment shall generally be comprised of modular capacitor steps complete with protection and switching devices.

7.4 Capacitors

The capacitor units shall consist of three single phase units connected in delta to form a three-phase capacitor. The three phase capacitors shall have the following characteristics:

Table 7: Three Phase Capacitors Characteristics

Item	Description
Double insulation	Capacitors shall be double insulated and have no earthing requirements
Self-extinguishing polyurethane resin casting	Non-corrosive and suitable for indoor installation
Capacitor coils coated under vacuum	Internal electric protection for each coil with overpressure disconnecting device
Terminals	Brass and non-overlapping terminals
Monobloc	Connections between terminals shall be welded and coated with resin
Self-healing metallised polypropylene film	To maintain capacitor coil operation in case of dielectric breakdown
Dry type (no oil)	No oil to minimise risk of leakage or fire
Discharge resistors	Rated to reduce capacitor voltage to less than 50 volts within one minute of disconnection

The capacitor units shall comply with the requirements of AS/NZS 1013 Shunt Capacitors for Connection to Power Frequency Systems.

The capacitor units shall be fitted with suitably rated discharge resistors. These discharge resistors shall be capable of reducing the capacitor terminal voltage below 50V within one minute of disconnection.

Capacitors shall be type-tested with type test certificates provided.

The capacitors shall be designed and installed to continuously withstand 130% of the nominal capacitor current in accordance with AS/NZS 3000.

7.5 Harmonic Performance

The power factor correction equipment shall be suitable for use on the existing power supply system for all operating conditions and shall comply with the relevant part of the AS/NZS 61000.3.x suite of standards.

Reactors or equivalent equipment shall be provided where required to protect the power factor correction equipment from harmonic currents which may arise on the existing power supply system under all possible operating conditions.

7.6 Harmonic Reactors

Harmonic reactors shall be 7% of the capacitors impedance to avoid or minimise resonance under all operating conditions. The rating of the reactors shall not be less than 1.25 times the rated capacitor current and shall be designed to carry 1.5 times the rated capacitor current without saturating.

Reactors shall be air cooled with copper conductors and class F insulation. Reactors shall be rigidly constructed and mounted in an approved manner to minimise noise.

7.7 Controller

The capacitor switching system shall provide automatic and manual control of the switching of the individual capacitor units so as to maintain the required power factor.

The power factor controller shall be microprocessor based and shall have the following features:

- Automatic self-adjustment to any capacitor step value;
- Digital indication of power factor;
- No-volt release to automatically disconnect all capacitors in the event of power failure;
- TTL interface;
- Plug in terminal connection;
- Indication of number of switching operations per step;
- Indication of capacitor size;
- Visual display of target power factor alarm; and
- Visual display of harmonic overload alarm.

8 VARIABLE SPEED DRIVES

8.1 Standards

IEC 61000	Electromagnetic compatibility (EMC)
AS/NZS 60529	Degrees of Protection Provided by Enclosures (IP Code)
AS/NZS 60947.4.2	Low-voltage switchgear and control gear: Contactors and motor starters – AC semiconductor motor controllers and starters

8.2 Design

8.2.1 General

Variable speed drives shall be selected to match the pump motor operation and have a continuous maximum rating of not less than the full output rating of the connected motor while operating under ambient conditions.

The variable frequency controller shall be of the variable voltage variable frequency converter fed type suitable for operating a standard squirrel-cage induction motor direct coupled to the driven equipment.

The controller shall be a fully microprocessor based solid state electronic type unit with all set-up and operating parameters entered/displayed via an integral keypad and digital display console.

8.2.2 Enclosure

Each controller and associated equipment shall be housed in a switchgear and controlgear assembly constructed to the applicable requirements of Section 6.1. For indoor applications, VSDs weighing over 11 kilograms are not to be housed in a separate SCA assembly. Where VSDs weighing less than 11 kilograms can be mounted in a separate SCA assembly without hampering maintenance, the SCA assembly may be installed on the wall or floor-mounted to suit.

The maximum size of any VSD enclosure penetration shall be designed to limit RFI radiation.

Ventilation of the enclosure shall be provided to ensure components do not overheat. Switchroom ambient conditions shall be taken into consideration in selecting the VSD with respect to cooling features of the VSD. A high quality, replaceable air filter element shall be fitted to the enclosure air intake. If a cooling fan is required, a quiet running centrifugal type shall be used.

8.2.3 Performance

Power Factor

Not less than 0.95 at all speeds and loads.

Motor Noise

The design and operation of the controller is to be such that internal switching frequency of the controller does not result in the output of additional audible noise beyond that which is experienced in a 50 Hz fixed speed application. The PWM carrier frequency shall be adjustable to minimise the high frequency audio noise produced at the motor. Adjustment in the range 2 to 14 kHz is required.

If necessary, harmonic filtering equipment shall be included.

Radio Frequency Interference

Controllers shall not cause interference external to the controller that would exceed the limits set down in AS/NZS CISPR 11. The controllers shall include integral RFI filters to meet these requirements.

Provide test certificates demonstrating compliance with these requirements.

Speed Control

The controller shall allow the associated motor speed to be continuously varied over a speed ratio of at least 25:1. Operation over this range shall be stable and regulation within ±2% not withstanding variations in temperature, supply voltage or other external or internal variables. Acceleration and deceleration shall be adjustable to at least 0 to 50 seconds to ensure smooth ramping of speed and avoid tripping of protection circuits.

Efficiency

The total VSD efficiency including converter, inverter, harmonic filter, capacitors and auxiliaries shall be a minimum of 96% at full load and full speed.

Diagnostics

The controller shall have a full suite of diagnostic software tools to facilitate commissioning and fault finding.

8.3 Operation

The controller design shall incorporate an integral line contactor to start and stop the drive power circuits. When the drive is started it shall uniformly ramp the motor speed to the setting of the speed control device/signal. The rate of acceleration shall be an adjustable parameter.

8.4 Harmonic Distortion

In general, the maximum AC harmonic distortion, including voltage notching caused by the controller shall not exceed the limits set down in AS/NZS 61000.3.6, however, the design of variable speed drives shall be coordinated with the assessment of harmonic emissions for the power system of the whole site.

Electromagnetic interference emitted by the equipment shall be within the limits specified in AS/NZS 61800.3.

If filters are used, the filters shall be integral to the VSD and designed to prevent any harmonic resonance in the operating speed range.

8.5 Controls

Control equipment and indications shall be provided to allow for remote and local control of the controllers/connected equipment.

24 VDC shall be used for the control voltage and separate from the power circuit supply.

The following control equipment and indications are to be provided for speed control of the controller:

- Auto/Off/Manual control selection;

- Manual speed control potentiometer or adjustment (keypad entry, etc.);
- Digital speed indicator to show motor speed from 0 to 100%; and
- Auto speed control input from an external 4 to 20 mA DC signal when auto control is selected.

Where integral control 'status' contacts are used in externally supplied circuits, the fault capacity shall be higher than that of the circuit protection device in that circuit or provide additional protection if necessary, within the VSD controller.

8.6 Protection

Protection features shall, as a minimum, include:

- Motor overload;
- Over-temperature protection;
- Instantaneous overcurrent and overvoltage trip;
- Instantaneous earth fault;
- Undervoltage and loss of power;
- Input and output loss of phase;
- Thermistor protection; and
- Motor stall protection.

Protection equipment shall be arranged to trip the controller when operated and to prevent restarting of the controller until manually reset. Where reset push-buttons external to the VSD control panel are warranted in the design, they shall be mounted on the front of the enclosure.

Each type of fault shall be individually indicated on the front of the enclosure containing the controller and associated equipment. Fault indications shall remain active after the controller has been stopped and or tripped due to the fault condition.

8.7 Motor Cabling

All cabling between VSD controller and the motor shall be installed in screened type power cable to the manufacturer's recommendations. Steel wire armoured cable is not acceptable. The VSD system shall be designed such that the motor insulation system is not compromised thermally due to dV/dt stresses.

8.8 Testing

Perform on-site testing once all controllers are installed and operating to verify compliance with harmonic distortion and radio frequency interference requirements specified. Test certification shall be provided to demonstrate stated VSD efficiencies.

9 SOFT STARTERS

Where soft starters are required to limit the motor current at starting whilst providing sufficient torque for smooth acceleration, they shall incorporate the following features:

- separate current limit and voltage ramp adjustment;
- microprocessor based;
- six solid state switches, one pair per phase;
- breakaway torque adjustment;
- extended stop time;
- transient protection;
- ramp time adjustment;
- radio frequency interference suppression unit;
- LED diagnostic indication and status panel for mounting on the motor starter doors;
- system protection, such as overload , short circuit and motor stall protection; and
- bypass contactor.

10 CABLES

10.1 General

All conductors shall be annealed high conductivity copper in accordance with AS/NZS 1125.

Power and control conductors shall not be incorporated in the same cable unless specified or approved.

Single strand conductors shall not be used. The minimum conductor sizes shall be:

Internal Control Cubicle Wiring	1.5 mm²
Instrumentation Cabling (including ELV PLC I/O Cabling)	0.5 mm²
Control Cabling	1.5 mm²
Power Cabling (230 VAC)	2.5 mm²
Power Cabling (24 VDC)	1.5 mm2
Lighting Cabling	1.5 mm²

Power cables shall be sized according to the following considerations:

1. Current rating in accordance with AS/NZS 3008.1
2. Short circuit rating in accordance with AS/NZS 3008.1.
3. Motor supply cables shall produce a maximum voltage drop of 20% on starting at the motor terminals.
4. Feeder cables shall give a maximum voltage drop of 5% at the busbars when the largest load or motor is started with all other loads running.
5. Steady state voltage drop shall not exceed 5% under any circumstances.

Instrumentation cabling shall be designed to ensure that adequate voltage is present at the instrument/equipment terminations to allow correct operation and within the tolerances of the instrument/equipment as specified by the manufacturer.

10.2 Size and Rating of Equipment

All mains, submains, and final sub-circuit cables shall be sized according to the loads of selected equipment. Circuit breaker ratings and settings shall ensure all cables are protected under fault conditions.

10.3 Wire Identification

Cable cores shall be numbered and coloured as follows:

WIRE IDENTIFICATION CODE

Function	Colour
400 VAC	Red, White and Blue

WIRE IDENTIFICATION CODE

Function	Colour
230 VAC (Controlled from within panel)	Active – Red, White and Blue for phase wiring Neutral – Black
230 VAC (Not controlled from within panel)	Active – Orange Neutral – Black
ELV AC	Active – Brown/Red stripe Neutral – Brown/White stripe
DC, all voltages	(+) ve – Blue/Red stripe (-) ve - Blue/White stripe
Earths	Green/Yellow stripe
Telemetry/SCADA	Violet
Field instrument cabling	White/Black twisted pairs

10.4 PVC Insulated Cables

Cables shall be PVC insulated to V75 specification.

All cables, excepting panel wiring, shall be double insulated.

Control cables shall have white core insulation bearing black core numbers and a green with yellow stripe insulated earth.

Twisted pair instrumentation cables shall be screened with each pair numbered.

10.5 Cross Linked Polyethylene Cables (XLPE)

XLPE cables for voltages up to 0.6/1 kV shall comply with AS/NZS 5000.

10.6 Instrumentation and Control Cables

Instrumentation and control cables shall be multicore PVC insulated and sheathed 0.6/1 kV underground type with stranded copper conductors having a cross sectional area of no less than 1.5 mm^2. Each conductor shall be numbered at intervals not exceeding 100 m. Numbering shall be in accordance with wiring diagrams at each terminal.

Instrument signal cables shall be insulated and sheathed electronic instrument type (such as Dekoron®) with stranded copper conductors having a cross sectional area of not less than 0.5 mm^2. Each pair of conductors shall be twisted to reduce inductively coupled magnetic noise and each cable shall have individually and overall screened pairs to reduce capacity coupled static noise. Sheath colour shall be black. Earthing of the screen shall be at the control panel only and shall be achieved by connection to the instrument earth busbar, insulated from protective earth.

10.7 Cables for Hazardous Areas

Cables for explosive atmosphere applications shall be suitably rated and meet the requirements of AS/NZS 60079.10 for the determined classification of the area and the AS/NZS 60079 series of standards covering explosive atmospheres.

10.8 Optical Fibre Cables

Where optical fibre cabling is required, it shall satisfy the following requirements as a minimum:

- Optical fibre cabling shall be installed in a minimum 50 mm diameter conduit.
- Optical fibre shall be multi-core as determined by the specific design, single mode, non-armoured, loose tube type suitable for underground installations and routing. Data sheets in respect of optical fibre shall be submitted to the Principal's Authorised Person for approval.
- Ethernet-fibre media converters shall be fully compatible with the optical fibre supplied.
- For optical fibre cables terminated into a fibre optic break out tray, a minimum of 15 m of cable shall be stored/coiled in the nearest adjacent pit. A minimum of 3 m of cable for splicing shall be provided.
- Optical fibres cables shall be continuous and have no breaks/terminations other than at the beginning and end of the run where the fibre terminates to a fibre optic break out tray at the respective enclosures. Splicing/joining of optical fibre cabling/cores along a route is prohibited.
- Care shall be taken during installation of optical fibre. The cable shall not be subjected to high pulling tensions or stresses. Any equipment used to pull cables shall be fitted with tension monitor and an automatic shutdown device calibrated to operate when the pre-set maximum pulling tension, as identified in the cable manufacturer's data sheets, is reached.
- Cables shall not be bent beyond the maximum bending radii as detailed in the manufacturer's cable data sheets.
- All installation works shall be coordinated with adjacent works to ensure cables are installed without damage or are not affected in any way by adjacent works activity.
- All optical fibre cabling and installations shall be tested in accordance with AS/NZS ISO/IEC14763.3:2012 Telecommunications installations – Implementation and operation of customer premises cabling Part 3: Testing of optical fibre cabling (ISO/IEC 14763.3:2011 MOD).
- The Contractor shall submit to the Principal's Authorised Person detailed testing documentation outlining tests performed and results obtained.

11 UNINTERRUPTIBLE POWER SUPPLY (UPS)

11.1 General

UPS shall be a three-phase input and output, 400 volts, 4 wire, true on-line uninterruptible power system rated as applicable to the specific requirements of the installation. The UPS shall convert its AC input into filtered DC voltage to charge the system battery and supply power to the inverter section. The inverter shall produce regulated and filtered AC power which, under normal operation, supplies the critical load via an electronic bypass switch.

The UPS shall be designed to operate with sealed lead acid maintenance free batteries.

In addition, the system shall contain a static bypass switch to connect the critical load to an alternate power source in the event of a UPS internal failure and in the case of overloads or short circuits. This bypass shall be rated for continuous duty at 150% of rating and 200% for 1 minute.

The UPS shall have the ability to be placed into a “master-slave” configuration on site without disruption to the critical load.

The UPS shall comply with the current version of the AS/NZS 62040 series of standards.

11.2 Component Ratings

The system shall be designed in such a way that all electronic components operate at no more than 80% of their absolute ratings. All other electrical components shall be appropriately rated as per the standards and industry best practice.

11.3 System Components

11.3.1 General

The proposed equipment shall contain the following basic components and subassemblies:

- Input circuit breaker or fuse switch, with an appropriate rating
- Digital control of rectifier/charger of sufficient rating to support the operation of the inverter at full load and recharge the battery in the specified time
- IGBT technology and instantaneous control of the inverter
- Digital control of static transfer switch and
- Maintenance bypass switch gear which can supply power to the critical load while isolating internal UPS components from the input power and the load

11.3.2 Rectifier/Battery Charger

The rectifier shall be 6 or 12 pulse design configuration and be digitally controlled. Rectifiers shall be protected by a circuit breaker.

11.3.3 Automatic Charge Control

The rectifier/charger shall be optionally capable of automatically providing discharge time dependent boost charge over an adjustable period suitable for lead acid and NiCad batteries. Current limiting shall be provided. The rectifier shall be capable of reduced current limiting for operation with a standby engine generator.

11.3.4 Inverter and Output Transformer/Filter

The inverter section shall be a pulse width modulated design. The power semiconductors in the inverters shall be silicon, bi-polar transistors or Insulated Gate Bipolar Transistors (IGBT). Inverters shall be fuse protected and incorporate transistor desaturation protection.

The output frequency shall remain synchronised to the input frequency, over an adjustable time during load and line transients.

The inverter logic shall provide current limit protection for the inverter. The protection shall be sufficient to allow a direct short to be applied to the output without damage to any components within the inverter.

11.3.5 Battery

The UPS shall operate with a battery bank made up of maintenance-free, sealed lead acid batteries. Batteries can be internal or housed in a steel cabinet of similar dimensions to the UPS.

Adequate ventilation shall be provided such that any gases that could potentially be released from failing batteries do not reach toxic/dangerous levels. Ventilation requirements shall comply with the relevant clauses of AS/NZS 62040.1.1.

The design of batteries shall be a minimum of 5 years.

11.3.6 Static Transfer Switch

The static transfer switch shall be an electronic switch employing 6 silicon-controlled rectifiers (SCRs) to connect the bypass source to the load, under conditions of inverter overload or failure. The static switch shall be digitally controlled. On removal of overloads the switch shall reconnect the load to the inverter output automatically. Manual reconnect may be selected if required.

11.4 Performance

The following describes the minimum electrical performance of an on-line reverse transfer UPS system:

Table 8: UPS Characteristics

Characteristics	
Voltage Tolerance	400 VAC 3 Phase ± 10%
Frequency Tolerance	50 Hz ± 5%
Power Factor	Greater than 0.8 at full load & input voltage.
Walk In	2 seconds programmable from 0 – 100% load.
Current Inrush	The input current shall not exceed 125% of full load output current.
Protection	Fuses and/or circuit breakers
Rectifier/Charger	
Type	6 or 12 pulse, phase Controlled S.C.R.
Input Tolerance	400 VAC 3 Phase ± 10%
Rated Input Power with Charged Battery	As applicable
Input Power Factor	Greater than 0.80 lag
Rated Output Voltage	250 VDC
Float Voltage Adjustment	± 15%
Voltage Ripple	1% RMS
Battery Specifications:	
Battery backup time	As applicable to the specific requirements of the project
Protection	Low voltage automatic inverter
Inverter Data:	
Inverter Type	Transistorised or Insulated Gate Bipolar Transistor (IGBT), pulse width modulated, and transformer isolated
Output Current – Full Load @ 0.8pf	As applicable
Efficiency -	Greater than 92%
Load Power Factor	At nominal load 0.7 lead - 0.8 lag At reduced load 0.5 lead to 0.5 lag
Voltage Regulation	Static balanced load ± 1% Static 100% unbalanced ± 1% load Dynamic 50% load step ± 4% Dynamic 100% load step ± 5%
Voltage Transient Recovery Time (to ± 2%)	Less than 50 ms.
Short Circuit Current	150%
Nominal Frequency	50Hz
Overload Capacity	Inverter: 125% 10 minutes 150 % 1 minutes Static Bypass: 2000% 20 ms 200% 1 minutes 150% continually

11.5 Cabinets

All UPS equipment supplied under this Standard shall be housed in cabinets and enclosures to IP20 degree of protection for installation indoors. The enclosure shall have doors or removable panels which allow free access to all components for service and replacement. Doors shall be equipped with a special access key. Cabinets which house forced air cooled components shall be designed to permit air to enter at floor level and exit at the top rear. Bottom entry shall be provided for AC Input, AC output and battery power cables.

11.6 Materials

Any metal parts which are subject to corrosion shall be plated, painted or otherwise treated to prevent corrosion and other effects of ageing. All materials used in the equipment shall meet the requirements for flammability and dielectric properties as set forth in the applicable Australian and International Standards.

11.7 Component Marking

All components shall be clearly and permanently marked with appropriate part number or reference designators so that there will be no confusion as to proper identification during operation or service.

11.8 Access and Serviceability

All sections of the supplied equipment shall be designed and constructed to allow for easy access and service for all components. Once installed, minimum access to the sides and rear of the equipment shall only be required to perform routine service. The equipment shall be constructed in a modular manner which allows for quick replacement of components and assemblies. Diagnostic alarms and LEDs shall provide for rapid diagnosis and repairs by suitably trained service personnel.

11.9 Cooling

Forced air cooling shall be employed. In the event of fan failure, the UPS shall continue to function normally. An over temperature warning shall be provided. Should temperature continue to rise, an over temperature shut down circuit shall shut off the UPS and the load shall transfer to the bypass source if available.

11.10 Labelling and Indications

The UPS shall have a mimic diagram, in a block diagram form, with integrated LEDs which allow a quick check of the UPS status.

As a minimum requirement the LEDs shall indicate:

- Mains present
- Rectifier status
- Battery switch status
- Battery discharging
- Static bypass status
- Maintenance bypass switch status
- Inverter status
- Load fed by inverter status
- Load fed by static bypass
- Load is supplied
- Battery test

- Emergency power off status
- Static switch
- Battery indicator
- Load percentage and
- Common alarm

11.11 Alarms

The following alarm conditions shall be communicated externally by means of voltage free relay contacts.

- AC Mains OK;
- Load fed by AC Mains; and
- Load fed by Inverter.

12 FIELD EQUIPMENT AND INSTRUMENTS

12.1 Local Control Stations

The term local control station (LCS) in this section shall be taken to include all associated works including mounts/foundations, base, stands, sunhoods, equipment and enclosures installed outdoors. The LCS may be a minor distribution board for distribution of power to a small number of local equipment, in which case such an application will be of Form 1 construction in accordance with AS/NZS 613439.1

The LCS shall be constructed of 2 mm marine grade aluminium or 1.6 mm grade 316 stainless steel with sunhood and supported on a marine grade aluminium channel post and base with cover plates. The LCS equipment enclosure shall be sufficiently deep for at least two contact blocks to be used or have available a replaceable lid which will enable the use of two contact blocks per operator. Terminal strips shall be provided for all cabling other than motor sub-circuits. A safety strap shall be installed to support open front cover if not supported by hinges.

The LCS shall not be used for the looping or marshalling of cables.

A sample LCS (equipment enclosure only) shall be submitted for approval to the Principal prior to mass fabrication and/or supply. This sample shall be of the type to be provided under this Contract and include typical equipment, terminals, ferrules, internal wiring and glanded external cabling with cable protection.

12.2 Junction Boxes

Junction boxes shall be used for the marshalling and looping of all field cabling and shall be constructed of 2 mm marine grade aluminium or 1.6 mm grade 316 stainless steel, as applicable to the environment in which the junction boxes will be installed. Junctions shall be effected through terminal strips within the junction box. The terminal strips shall be provided with 25% spare terminals in addition to that provided for initial requirements.

Separate junction boxes shall be provided for each different drive or equipment system if they serve as a disconnection point, to inhibit live work.

12.3 Instrument Enclosures

All instrument units, terminals, power supplies etc. shall be mounted in Grade 316 stainless steel enclosures to a minimum protection rating of IP 66 (AS/NZS 60529).

Enclosures shall be drilled at the base to accept cable entry via cable glands. All spare glanded entries shall be plugged with a suitably sized sealing plug. The required IP integrity of the enclosure shall always be maintained.

For instruments and instrumentation enclosures mounted outdoors, provide additional protection from rain and sun by installing rain hoods and sun shields constructed from minimum 1.6 mm fully welded stainless steel. Mounting of instrumentation is to be such that the orientation is to be “south-facing” unless otherwise approved. The rain hood/sunshade shall either be sloped away from the face of the instrument or have a vertical lip to stop water from dripping onto the face of the instrument.

Provide hot dip galvanised steel mounting posts for instruments as required and constructed of 150 mm x 75 mm x 8 mm steel channels or approved equivalent. A reinforced concrete 1m^2 hardstand

area shall be provided in front of the instrument enclosure to facilitate access. Neoprene washers shall be used to segregate dis-similar metals from potential corrosion.

12.4 Instrumentation

12.4.1 Environment

Instrumentation shall operate reliably over an ambient temperature range of -5°C to 50°C and between 5% to 95% relative humidity (non-condensing).

12.4.2 Instrumentation Generally

Instrument accuracy shall be to within ± 0.5% of span.

Microprocessor based instrumentation is preferred over analogue electronic type.

The instrument's range shall be as required and selected such that the normal working maximum to be measured is approximately 80% of the range unless otherwise approved. Scales for indicators and outputs shall be as required.

The units used for measured variables shall be in SI engineering units. Preferred units shall be confirmed by the Principal. Graduation shall be sufficient to allow reading to the accuracy of the measurement of the indicated variable. Multiplying factors, except those used in unit designations such as millimetre, are not acceptable. Instruments to be provided with indicators are to be mounted with the readout mounted at a location accessible by the operator without the need to use access ladders or open access covers. If necessary, additional indicators are to be provided to meet this requirement if the instrument is mounted in a location not accessible to the operator.

Instruments shall be suitable for continuous, unattended operation. Instruments shall maintain rated accuracy with a minimum of maintenance intervals or need for calibration and adjustment. Span/zero adjustment shall be by entry of parameters into microprocessor electronics via a keypad or similar.

Analogue signal outputs shall be live zero, isolated 4 to 20 mA DC suitable for input to a load of at least 600 ohms at 24 VDC. The signal shall be linear with respect to measured variable. Digital (on/off) signal outputs shall be volt free changeover contacts rated for at least 1 A at 240 VAC.

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

Instruments shall be unaffected by electromagnetic fields of a strength up to 10 volts per metre over a frequency range of 10 kHz to 1000 MHz. In any case, the operation of a 10 watt handheld radio within a distance of one metre is to have no effect on the operation of the instrumentation or any signal from the instrumentation for the entire route of any connected cabling.

Instruments shall not generate a level of electromagnetic interference that exceeds the limits defined in AS/NZS CISPR 11.

Sensor elements shall be provided with sufficient cable length for final mounting positions and shall be supplied by the instrument supplier for connection to the instrumentation transmitter.

12.4.3 Materials Generally

Materials used shall be suitable for use in the environment (e.g., a raw sewage environment) they will operate and be resistant to corrosion and UV light.

12.4.4 Instrument Pipework

All instrument pipework and valves shall be suitable for the application.

12.4.5 Calibration

All instrumentation shall be correctly calibrated for the intended application. A calibration certificate shall be provided for each instrument including all test results to demonstrate satisfactory measurement of the variable over the required range to the accuracy specified.

12.4.6 Instrument Tags

All primary measuring elements, transmitters and signal converters shall be tagged in accordance with an approved numbering system.

Instrument tags shall be stamped aluminium or stainless steel disks secured to the instrument via a stainless steel cable tie or wire.

12.4.7 Mounting

Mount all primary elements, transmitters and signal converters that do not mount directly in or on pipework or tapings in the instrument cubicle. Final location, arrangement and mounting of all instrumentation and associated equipment shall be to the Principal's approval.

All equipment shall be mounted in accordance with the manufacturer's recommendations.

12.4.8 Analogue and Switched Control Signals

Where instruments interface with analogue 'field' instruments as either inputs or outputs, the analogue transmission signal level shall be 4 – 20 mA live zero DC current. The analogue signal level within the SCA may be any standard live (+ or -) zero DC voltage or current to suit the instruments offered. Outputs shall be capable of accommodating a range of load impedance consistent with reasonable flexibility of instrumentation at the receiving end.

Any switched instrumentation control signals to or from field devices shall employ clean voltage free contacts.

Maximum attention shall be given to the termination of signal wire screens and earthing wires to and from field mounted devices to avoid multiple ground loops. Refer to Section 10.6.

12.4.9 Instrument Relays

Relays used in control cubicles for instrumentation circuits shall be miniature hermetically sealed plug-in types with coils continuously rated at the nominated instrumentation circuit voltage. Coil operating currents shall not exceed 200 mA. Contacts providing inputs to RTU equipment shall reliably switch 24 VDC to 5 mA.

Silicon semiconductor (freewheeling) diodes of adequate voltage and current rating shall be connected across these relay coils to prevent damage to transistor or integrated circuit output stages due to voltage spikes seen across inductive loads experiencing a sudden loss of current.

12.4.10 Wiring

Wiring within instrument cubicles shall be neatly arranged and wherever practicable groups of wire shall be contained in capped plastic ducting. Elsewhere, groups of wire shall be strapped together with nylon, or other strong plastic ties or spiral binding to form neat wiring bundles. The use of

adhesive tape to contain or secure wire groups is prohibited. Electrical wiring methods shall be in accordance with the requirements of AS/NZS 3000.

All instrument wiring shall be colour coded to standard colours. Refer to **Error! Reference source not found.**.

Table 9: Wiring Sheath Colours and Minimum Sizes

Wire Colours		
Phases	Red / White / Blue	
Neutral	Black	
240 VAC	White	
12 / 24 VDC	Blue / Red	Blue / White
12 / 24 VAC	Brown / Red	Brown / White
Minimum Cable Sizes		
Power	2.5 mm^2	
Control	1.5 mm^2	
Instrumentation	0.5 mm^2	

12.4.11 Lightning and Surge Protection

Lightning and surge protection units shall be provided for field mounted analogue instruments.

12.4.12 Power Supply Units

Supply Voltage

The power supply shall be suitable for connection to a 230 V +/- 10%, 50 Hz +/- 2% single phase supply.

Standards Compliance

The power supplies shall comply with relevant standards for electromagnetic emissions, immunity and electrical safety.

Isolation

The power supply shall be fed from a 230/24 VAC isolation transformer with interwinding earth screen.

Rating

The power supply rating shall be a minimum of 125% of the connected load.

Ripple Voltage

The maximum ripple voltage at the output shall not exceed 20 mV p/p.

Overload Protection

The power supply shall be fully protected against overloads. The design shall incorporate linear fold back limiting, thermal protection and short circuit protection. The power supply shall be capable of withstanding an indefinite overload or an indefinite output short circuit. Removal of the overload or short circuit shall result in the immediate correct functioning of the power supply.

Output Overvoltage Protection

The unit shall incorporate overvoltage protection to disconnect the power supply from the load if the power supply output voltage exceeds 26 V. This function shall be self-resetting.

Power Supply Fail Relay

Incorporate a dry changeover relay contact to indicate that the power supply voltage is within acceptable limits. If the output is over 26 V the relay shall de-energize. The relay shall not re-energize until the power supply falls below 25 V. If the power supply voltage falls below 22 V the relay shall de-energize. The relay shall not re-energize until the power supply exceeds 23 V.

LED Indication

The power supply unit shall have an LED to indicate 'Power Supply ON / OK'.

Discharge Capacitor

Provide a discharge capacitor in the output circuit, to trip the 24 VDC distribution circuit breaker on a faulty circuit.

Terminals

The power supply shall have separate terminals for connection of the load and relay contacts including an extra negative output terminal for earthing such that only one wire need be placed in each terminal. All terminals shall incorporate wire protection clamps and accommodate up to 2.5 mm^2 cable.

Surge protection

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

The surge reduction filter shall be rated at 250 VAC, 40 kA on a single shot 8/20 µs impulse and shall be capable of continuous supply of 10 A. The maximum let-through voltage of the device shall be 500 V. A surge diversion failure indicator shall be provided which shall be clearly visible on the switchboard front panel without the need to open doors.

12.4.13 Electromagnetic Flowmeters

General

Electromagetic flowmeters shall be of the self-zeroing pulsed DC field design with remotely mounted signal converters. Flowmeters shall be suitable for use in empty pipes without the need to de-activate the flowmeter. The Principal prefers that all magnetic flow meters be of the same brand and manufacturer. Refer to Section 3.4.

Meter Tube

Meter tubes shall be of short form pattern with an internal abrasion. Corrosion resistant neoprene lining suitable for wastewater service shall also be provided for wastewater applications. All external

surfaces shall be protected against corrosion through either the use of suitable materials of construction or through the use of a suitable corrosion resistant surface finish.

Meter tube flange drillings shall be to AS4087, Class 16. The flowmeter shall be rated to suit the required test and working pressures.

Enclosure of electrical components and devices attached to the metering tube shall be rated IP68 (submersible to 5 meters and suitable for buried service). Cable entries shall be via suitable cable glands consistent with enclosure class.

Earthing rings constructed of 316 SS shall be provided, one on each side of the instrument's flanges, including associated connections, earthing straps and gaskets as necessary. The earthing rings shall be installed and wired as per the instrument manufacturer's instructions.

Electrodes shall be selected based on the most appropriate material and shall consider chemical compatibility, corrosion and abrasion resistance to the process media they will be subjected to.

Signal converter

The signal derived from the meter tube shall be converted to an isolated 4-20 mA DC output current linear with flow via a signal converter.

The converter shall be microprocessor based and have an integral LCD backlit display of two (2) lines. The upper line on the display shall show the instantaneous flowrate and the second line shall display a re-settable totaliser.

The instantaneous flowrate indicator shall have selectable engineering units.

The converter shall have a passive scale pulse output with an adjustable pulse rate and pulse width.

The converter shall have configurable maximum and/or minimum process flow alarm contacts.

The configuration of the converter shall be achieved through access keys on the front panel and be menu driven. The menu system shall be self-explanatory so that no programming knowledge is required to configure the converter.

Totaliser values and configuration shall be maintained in the event of power failure.

Surge protection for the 230 VAC 50 Hz supply, 4-20 mA signal and pulse outputs shall be supplied and be housed in the one enclosure and shall be compatible with the flow converter. The flow converter and surge protection unit shall be located together.

Connection

Meter tubes shall be sized dimensionally as close as possible to the pipe size whilst maintaining velocity ranges that will provide accuracy in operation for the meter tube and signal converter.

If the meter tubes are slightly smaller in dimension than the pipe ID, then protection flanges shall be fitted to the inlet side of the flow meter to protect the liner edge from erosion.

Meter tubes shall have interconnection and power cables terminated in the terminal box before delivery to site. These shall be suitable sealed and coated to ensure the IP68 rating.

Testing

The complete flowmeter comprising meter tube, signal converter and connecting cable shall be tested in a flow test rig to verify that calibration is correct and within overall accuracy tolerance. Calibration of the analog output is to be checked at 0%, 10%, 50%, 75% and 100% of span.

Calibration testing shall be performed at a suitably equipped NATA certified hydraulic laboratory and a certificate provided.

12.4.14 Turbidity Transmitter

Turbidity sensors shall be true nephelometric (NTP) instruments based on the scattering of a beam of light by particulate matters in the liquid sample. Both scattered and transmitted light is to be measured allowing compensation for lamp output variation. The lamp shall be operated below rated voltage to prolong life and supplied by a regulated source to minimise effects of power supply variations.

Sampling flow shall be arranged to allow calibration without interruption to the flow. A “de-bubbling” device shall be provided to effectively remove air bubbles prior to the turbidimeter.

A permanent turbidity reference standard shall be provided to assist in calibration. A “dry” type standard is preferred over chemical preparation type standards.

The transmitter shall have a 4-20 mA output. The 4-20 mA output for the system shall be wired to the PLC / RTU analogue input.

12.4.15 pH Transmitter

pH systems shall have the following features:

- Jet cleaning systems using compressed air (where available) to clean the pH sensors;
- 4-20 mA output for pH. The 4-20 mA output for the system shall be wired to the plant PLC / RTU; and
- Relay outputs wired to the plant PLC / RTU.

Provide two spare electrodes for each sensor. These shall be tagged to the instrument they belong to, ensuring the correct sensor is used.

It shall be part of the scope of the instrument supply to have the instrument supplier representative on site to set up, test and commission the pH systems during the site testing period.

12.4.16 ORP Monitoring System

ORP systems shall have the following features:

- Jet cleaning systems using compressed air to clean the ORP sensors;
- 4-20 mA output for ORP. The 4-20 mA output for the system shall be wired to the plant PLC/RTU; and
- Relay inputs and outputs wired to the plant PLC / RTU.

Provide two spare electrodes for each sensor. These shall be tagged to the instrument they belong to, ensuring the correct sensor is used.

It shall be part of the scope of the instrument supply to have a Royce representative on site to set up, test and commission the ORP systems during the site testing period.

12.4.17 Dissolved Oxygen Analyser

Dissolved Oxygen analysers shall have the following features:

- Incorporate a self-cleaning head system; and
- Have a 4-20 mA output. The 4-20 mA output for the system shall be wired to the auto control PLC analogue input card.

Provide two spare electrodes for each sensor. These shall be tagged to the instrument they belong to, ensuring the correct sensor is used.

12.4.18 Residual Chlorine Analyser

Residual Chlorine analysers shall have a 4-20 mA output. The 4-20 mA output for the system shall be wired to the plant PLC / RTU.

12.4.19 Flow Measurement

Rotameter (Variable Area Flowmeter)

Each rotameter shall be of the tapered tube and float type, of straight through construction, with flanged or threaded end connections as required.

The flowmeters shall have tempered glass tubes, stainless steel end fittings and stainless steel floats. The flow meters shall incorporate a metering tube that can be removed and cleaned without removing the meter body from the line.

The flow meters shall be selected to suit the range for each individual application and shall be accurate to ± 2% of full scale over a minimum turndown ratio of 10:1. The flow meters shall be fitted with a direct reading scale, nominally 250 mm long and scaled in litres/second as appropriate for the flow ranges of each application.

Where switching is required, a magnetically activated switch arrangement providing a voltage free contact shall be provided for 2 wire connection.

Rotameter (Purgemeter)

The flowmeters required for monitoring purge air flow shall include an integral inlet needle valve to allow adjustment of the flow of air.

Each rotameter shall be of the tapered tube and float type, of straight through construction with screwed end connections.

All materials shall be suitable for the application.

The flowmeters shall be selected to suit the range for each individual application and shall be accurate to ± 2% of full scale over a minimum turndown rates of 10:1. The flow meter shall be fitted with a direct reading scale, nominally 70 mm long and scaled in litre/second or as appropriate for the flow ranges of each application.

Open Channel Flow Meter (Ultrasonic Level Sensing Type)

Ultrasonic open channel flow instruments shall have the specifications similar to the ultrasonic level instruments. Ultrasonic flow instruments shall provide the following features:

- Separate LCD digital displays with 4 digits of flow in L/s and totalised flow in kL
- Microprocessor based
- Capable of providing a 4-20 mA analogue output proportional to flow
- Provided with a pulsed contact for volume set at 1 pulse/kL
- Provided with a fault safe relay, a sampling relay, at least 2 output relays and LED status
- ± 0.2% maximum linearity error at 25°C and

It shall be part of the scope of the instrument supply to obtain the flume HQ curve and calibrate the flow meter to suit.

Orifice Plate / Differential Pressure Transmitter Mass Flowmeter

The differential pressure transmitter shall be loop powered and shall provide a 4-20 mA output signal proportional to the calculated flow rate.

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

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

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

12.4.20 Level Measurement

Level Transmitters (Ultrasonic Type)

Provision shall be made at the transmitter for independently adjustable span and zero adjustment and adjustable internal damping. The transmitter shall incorporate a digital indicator. Accuracy shall not be less than ± 0.25% of maximum range or 6mm, whichever is the greater.

Level Transmitters (Hydrostatic Type)

Level transmitters shall be of the capacitance sensing type for continuous measurement of the water level within tanks, storages or pump wells. The capacitance change shall be directly proportional to the depth of wastewater/reclaimed water above the capacitance sensor probe. Probe cabling shall incorporate a breather tube.

The probe assembly is to terminate within the supplier proprietary termination box and provide for transmission of signal to an opto-isolator and capacitance level indicator.

The 4-20 mA output signal shall be displayed as percentage full on a panel mounted level indicator and then wired to the plant PLC.

Each sensor shall be installed in a PVC stilling tube. The diaphragm end (sensing end) of the sensor element shall be fitted with a protective head to provide protection against knocks and be sufficiently clear of the base of tanks and wells in order not to allow any caking from the settling of solids which will inhibit the operation of the sensor. The stilling well shall be drilled with adequately sized weep

holes along the length of the tube to allow the tube to fill and drain correctly as the level in the tank or wells varies.

Level Sensing Relays and Probes

Level sensing relays and probes shall have differential action with sensors operating at extra low voltage AC. Sensor shall be either stainless steel rods or cable supported single or multipoint sensors. Sensor mounting brackets shall be 316 stainless steel and where cable supported sensors are used the cable shall be clamped between two plates in position. The sensing relay shall have adjustable sensitivity with a latched output between top and bottom sensors.

Minimum contact rating shall be 5 Ampere 240 VAC-11.

Level Switches (Float Type I)

Each level switch shall be of the encapsulated immersible switch type for water and wastewater applications. Each shall be supplied complete with a sufficient length of heavy-duty flexible cable to provide a generous allowance for adjustment of the operating level.

All wetted materials shall be inherently noncorrosive material and entirely suitable for the application.

Each level switch shall be provided with a voltage free, changeover contact.

Level Switches (Float Type II)

Each level switch shall be of the float-activated bulkhead mounting type.

Float, stem and other wetted materials shall be constructed from inherently noncorrosive material and entirely suitable for the application.

Each level switch shall be provided with a voltage free, changeover contact.

Level Switches (Float Type III)

Each level switch shall be of the encapsulated, immersible mechanical switch type. Each shall be supplied complete with a sufficient length of heavy-duty flexible cable to provide a generous allowance for adjustment of the operating level.

All wetted materials shall be inherently noncorrosive material and entirely suitable for the application.

Each level switch shall be provided with a voltage free, changeover contact.

Level Switches (Paddle Type)

Level switches for sensing level of non-liquid bulk materials shall be of the motor driven rotating paddle type. The detection of material is achieved by a rotating paddle with the control signal changing when material impedes rotation of the paddle.

Shafts and paddles shall be constructed from materials which are corrosion resistant to the material being sensed.

The number and size of paddle vanes shall be selected as appropriate for the density of materials sensed.

The paddle switch sensing unit shall include controls to ensure that when material impedes the rotation of the paddle that all moving parts are stationary and no wear takes place.

Each paddle switch shall satisfy enclosure class IP65 or better and shall be provided with a voltage free, changeover contact output.

12.4.21 Temperature Measurement

RTDs

Unless otherwise specified, Resistance Temperature Detectors (RTD) shall be utilised for temperature measurement.

Each RTD shall include a 3-wire platinum resistance temperature detector complying with IEC 60751 (Ro = 100 Ω, also known as Pt100). The sensing element shall be sealed in a ceramic former and enclosed in a stainless steel sheath. Sensing currents of up to 10 mA shall not have a significant effect on accuracy.

Each RTD shall include a suitable connector head, with enclosure class equivalent to IP65 allowing cable entry via a compression type cable gland.

Thermowells shall be provided for installation of the RTDs. Thermowell material shall be 316 stainless steel. Inside diameter of the thermowells shall be sized to match the thermometer to permit easy removal whilst providing close contact for maximum heat transfer and fast accurate temperature measurement.

A Wake Frequency calculation shall be undertaken to determine or prove the required dimensions and suitability of the Thermowell based on process condition in the pipe or vessel. These calculations shall be issued to the Principal.

Installation of the RTD, including wiring to the associated resistance to current converter, shall comply with BS 1041 Part 3. A “3 wire” circuit shall be used between each RTD and the associated converter. The converter shall be located in the RTD connector head.

Resistance to current converters shall be of the “two wire” type deriving electrical power from the loop 24 VDC supply. Converters shall include continuously variable span and zero. The output shall be a 4-20 mA DC signal linear with respect to temperature.

Accuracy shall be ± 0.5% of span or better.

Thermocouples

Where specified or as otherwise required for the temperature range, thermocouple type sensors shall be utilised for temperature measurement.

Each thermocouple shall include a Type J or Type K, to suit temperature range, single element, ungrounded temperature detector. The sensing element shall be sealed in a ceramic former and enclosed in a stainless steel sheath.

Each thermocouple shall include a suitable connector head, with enclosure class equivalent to IP65 allowing cable entry via a compression type cable gland.

Thermowells shall be provided for installation of the thermocouples. Thermowell material shall be 316 stainless steel. Inside diameter of the thermowell shall be sized to match the thermocouple so as to permit ready removal whilst providing close contact for maximum heat transfer and fast accurate temperature measurement.

A Wake Frequency calculation shall be undertaken to determine or prove the required dimensions and suitability of the Thermowell based on process condition in the pipe or vessel. These calculations shall be issued to the Principal.

Thermocouples and signal converters shall be interconnected with wire that will maintain the specified accuracy of the temperature measurement. The converter shall be located in the thermocouple connector head.

Signal converters shall be of the “two wire” type deriving electrical power from the loop 24 VDC power supply. The output shall be a 4-20 mA DC signal linear with respect to temperature. Converters shall include continuously variable span and zero.

The converter shall include automation reference junction compensation and thermocouple burnout protection.

Accuracy shall be ± 0.5% of span or better.

12.4.22 Pressure Measurement

Pressure Transmitters

Each electronic pressure transmitter shall use a differential pressure cell arrangement. The pressure transmitter shall be loop powered and shall provide a 4-20mA output signal proportional to the measured differential pressure.

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

The transmitter shall include independently adjustable zero and span adjustment and adjustable internal signal damping.

Process connections shall be subject to detailed design. However, typical valve manifold arrangements shall be as follows:

- Two-valve manifolds shall be supplied with each gauge pressure transmitter
- Three-valve manifolds shall be supplied with each differential pressure transmitter

Diaphragm seals shall be considered in installations where the instrument comes into contact with process water that could foul, block, damage or corrode the instrument.

Pressure Switches

Pressure switches shall be a force balance, spring activated, adjustable differential action type fitted with a switching single pole changeover contact rated 5 Amp, 240 Volt, AC-11.

Table 10: Pressure Switches

Minimum Switching Differential:	5% of span
Indoor Enclosure Protection Rating:	IP 56
Outdoor Enclosure Protection Rating:	IP 66
Rating:	5 A, AC11
Sensing Element:	Stainless Steel

The adjustable set point range shall be such that the noted setpoint falls between 30% and 70% of the adjustable range. The switch shall be of the automatic reset type.

Pressure Gauges (Bourdon Tube)

All pressure gauges unless otherwise specified shall be of the Bourdon tube type and shall be fitted with a gauge isolating cock.

Pressure gauges shall have a concentric dial of 80 mm diameter unless otherwise specified and shall be calibrated in kPa with a range as specified. Where specified or as required, pressure gauges shall be liquid-filled and fitted with isolating diaphragm to ensure the process material does not foul the gauge.

Snubbers shall be fitted to pressure gauges subject to pulsations.

Where pipework is subject to mechanical vibration, pressure gauges shall be mounted adjacent to the pipework and connected to the process pipework via impulse tubing.

Impulse tubing shall be installed in a manner consistent with the process media being monitored. To avoid air bubbles or condensation fouling the pressure gauge, impulse tubing shall be sloped toward a pressure gauge sensing liquids and away for pressure gauges sensing gases. Capillary diaphragm seals may be considered. Block and bleed valves may also be considered.

Where specified or as otherwise required where gauges are subject to a process medium of high temperature that would affect operation, a siphon shall be provided to isolate the medium from direct contact with the gauge.

Pressure gauges shall be accurate to ± 1% of full scale.

13 INSTALLATION

13.1 Reticulation

13.1.1 Setting Out of Runs

General

Cables shall either be contained in conduit or cable ducting or alternatively secured to perforated cable tray. Power cables and signal cables shall not be run in the same conduit or duct or on the same cable tray. Such separation shall also apply to ducting and conduits on desks and on walls. Cables shall be run as one continuous length with no joins unless otherwise approved.

Minimum Requirements

The following are minimum guidelines when setting out cable runs:

- All cables and conduits shall be installed neatly
- Cables and conduits shall be installed parallel to walls, doors, building members and installed square wherever possible
- Chasing of walls, floors and ceilings shall only be done with approval by the Principal
- Conduits in chases shall be firmly fixed and concealed, with adequate cover to prevent cracking and provision for expansion and movement by approved methods
- Conduits shall be located within or behind cavities, skirting, fixtures or bulkheads in preference to chasing
- Cables and conduits in roof spaces shall be installed in consideration of being co-located with roof insulation and sarking and de-rated as necessary
- Cable runs under computer floors shall be installed on hot-dipped galvanised cable trays and
- Cables shall always be installed such that they can be disconnected, removed and replaced.

13.1.2 Underground Reticulation

Trenching – General

Trenching refers to all works associated with providing trenches for underground reticulation including excavation, backfilling, reinstatement as well as ancillary works such as drainage, shoring, bracing and other necessary temporary works during construction of the trenches.

All trenches, unless otherwise directed by the Principal, shall be excavated in ground to an even surface.

The line of the trench shall be kept perfectly straight and parallel to the planned alignment. The bottom shall be kept level across the trench and the sides as near the vertical as is practicable. Any cavities in the bottom of the trench shall be filled with selected sand, properly compacted to the proper grade.

Shoring shall be erected as necessary to effectively prevent the sides of the trench from running or falling into the excavation and to keep trenches free from water during all cable laying operations.

Where trenches are to be excavated across roads, the road pavement material shall be kept separate from other excavated material to allow for same being easily replaced after backfilling. If this is not achieved, provide the same consolidated depth of pavement material of the same quality as previously existed, compacted to the same density as surrounding material.

Provide all precautions necessary for the protection from injury of all existing drainpipes, electric and telephone conduits and other existing works and services wherever met with, or which are adjacent to the work, and to avoid damaging such drains, conduits or service connections or any fittings attached thereto.

Maintenance of Trenches Before Cabling Laying

Trenches shall be kept clean and maintained in good order and condition between the time of excavation and laying prior to cable laying. This maintenance includes all measures to divert any water interfering with the progress of the works, keeping the trenches and excavations free from water while the works are in progress, and preventing any injury to the works by water due to floods or other causes.

Proper and approved pumping equipment shall be used for keeping the trenches and excavations free from water while the works are in progress.

Trench Construction

After the excavation has been completed and approved, the trench shall be cleared of all sharp objects and a foundation layer of bedding sand shall be placed. Prior to backfilling, draw wires shall be re-installed in the ducts and the ends sealed with a non-setting mastic compound. Any caps or draw wires in spare ducts, which may have been disturbed, shall be reinstated.

Backfilling of the trench shall only commence after witnessing and approval of the trench installation by the Principal.

Backfilling

A layer of sand shall be laid over the cables with a minimum cover of 100 mm. The minimum depth of sand including bedding shall be 100 mm.

General backfill may comprise the excavated soil or imported soil or sand provided that any material in the soil will pass through a 50 mm screen or subject to the Principal's approval.

Backfilling is required to refill the full width of trench above the level specified for sand surround, back to natural surface level. Marker tape shall be incorporated during backfilling. In addition, cable protection slabs shall be used where required.

The compaction of the backfilling shall be to a density not less than the density of the existing adjacent material and to the entire satisfaction of the Principal. Backfilling shall be carefully placed in layers not exceeding 150 mm well-watered if necessary, then tamped and compacted with mechanical rammers.

In existing paved areas, the surface shall be reinstated to the original level and finish to the satisfaction of the Principal.

Excess spoil from the trench excavation not required for backfill in the trench shall be removed from site.

Cable Protection and Marker Tape

Mechanical protection shall be installed over direct buried cables for their entire route as required by AS/NZS 3000.

Cable Markers

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

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

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

Inspection of Trenches

All trenches shall be left ready for inspection by the Principal at the following stages of the work:

After laying the conduits, but before any backfilling or laying of marker tape; and

After laying marker tape.

13.1.3 Pits and Conduits

Pits

Construction: Pits, lids and the method of installation shall be suitable for the trafficable class duty anticipated in the area in which they are installed. Pits in roads shall be provided with “gatic” type covers suitable for the trafficable duty. Pits over 1000 mm in height shall be provided with iron step-ladders for safe access.

Marking: Lids to electrical pits shall be marked ‘Electrical’. Lids for communications pits shall be marked ‘Communications’.

Size: The cable pits shall be:

- Adequately sized accommodate the number of conduit entries.
- Allow the installation of cables without infringing on the minimum bending radius of cables, either during installation or when complete. In particular, the minimum length of cable pits shall not be less than 4 times the minimum bending radius of the largest cable.
- Of minimum dimensions 600 L x 600 W x 900 D, if not conflicting with the preceding criteria or indicated otherwise

Installation: Conduit entries into pits shall have bell mouthed ends. Pits in paved surfaces shall be installed at grade with the surrounding surface. Pits outside paved surfaces shall be installed 30mm above the surrounding surface and the surrounding ground graded up to the pit for a distance of 1 metre.

Drainage: Cable pits shall be drained with a 100 mm drain fitted with a non-return valve to a stormwater pit or where not practicable to a rubble soakage pit. The last pit prior to entry into the switchroom shall be built lower than the switchroom floor and drained to prevent water ingress into the switchroom via the pit and conduit system.

Conduits

General: All conduit types shall be selected to comply with the requirements of AS/NZS 3000 and the Wiring System (WS) classification system of AS/NZS 3013. All PVC conduits installed underground shall be installed in a similar manner as that outlined for a Category B system AS/NZS 3000. No wires shall be installed until all conduits are in place.

No conduit less than 20 mm shall be installed for any part of the installation.

All conduits shall have a minimum spare space capacity of 25% for future additions except where otherwise specified. A minimum of 25% spare conduits shall be provided for runs between external pits and between external pits and switch panels/switchrooms.

Installation: Conduits shall be installed in such a manner to allow easy draw-in and replacement of cables; draw-in boxes shall be used where necessary to enable draw in of long runs of cables and shall not exceed spacing of 20 m. A draw wire shall be installed in each conduit. The draw wire shall be tagged as such. A 1.5 mm2 zinc plated or galvanised steel draw wire shall be provided in all empty conduits. Material used to lubricate cables whilst drawing into conduit shall be dry, non-conductive, non-abrasive and non-hygroscopic.

Wherever inaccessible or concealed conduits change direction, the conduit shall be set with as large a radius as practicable. Field bends shall have a minimum bending radius of six times the enclosure diameter. Kinked or squashed enclosures are not acceptable.

Single conduit runs shall have their ends bushed via nylon bushings wherever cables exit onto neighbouring cable trays or to enclosures.

All screw or fastenings used for fixing conduit saddles shall be plated or galvanised.

During installation, the ends of conduits shall be temporarily plugged to prevent the ingress of dirt.

All runs to floor mounted equipment shall be laid in the floor slabs. Where overhead connections are approved, drops shall be neatly and adequately supported.

Conduit types: Conduits shall be of the type indicated in the following areas:

Table 11: Conduit Types

Method of Installation	Type
Buried in situ concrete	Rigid PVC
Buried in precast concrete	Screwed steel
Exposed to weather	Clipsal HFT or approved equivalent
Surface run in plant rooms etc	Galvanised screwed steel
Subject to mechanical damage	Galvanised screwed steel
Chased into rendered brickwork	Rigid PVC
Underground	Heavy duty UPVC

Rigid PVC Conduits: Rigid PVC Conduit and fittings shall be of high impact strength heavy gauge complying with AS/NZS 2053. All fittings and accessories shall be secured with an approved solvent cementing compound. Screwed joints shall not be permitted.

Rigid PVC conduit shall be installed so as to enable cables to be 'drawn-in' after erection and junction boxes are to be provided for this purpose. Inspection type fittings are not permitted as draw-in points.

Flexible Conduits: Unless otherwise indicated, flexible PVC (to AS/NZS 2053) or plastic covered flexible steel conduit (to AS/NZS 2052) shall be used for final connections to indoor lighting and small power. The length of flexible conduit shall be kept to the minimum necessary to make the connection and accommodate plant movement.

The flexible conduits shall be complete with oil tight, waterproof end fittings. Where cables are required to enter an enclosure via cable glands, the flexible conduit end fittings shall be attached via a bracket secured to the device or nearby structure at a short distance from the cable gland. Coupling adaptors shall be of the plated steel or brass type.

The flexible conduit type shall be suitable for the WS rating of the wiring system, hazardous area classification and the ambient conditions, such as sunlight, temperature, chemicals etc.

Steel Conduits: Steel conduits shall be heavy duty galvanised steel in accordance with AS/NZS 1074 and be of minimum 20 mm diameter.

Galvanised steel conduits shall be complete with all accessories such as junction boxes, bends, unions, locknuts, bushes, saddles, etc. Fittings shall comprise screwed elbows, tees, bends and draw-in boxes.

All galvanised steel conduit accessories such as junction boxes, bends, etc installed in the hazardous locations as defined by AS/NZS 2430 and shown on the drawings, shall be of the weatherproof and flameproof inspection type complying with AS/NZS 1826.

Steel conduits shall have their ends de-burred and fitted with an appropriate bush prior to running of any cables.

Surface Conduit Installation: Conduit run on the surface and exposed to view shall be run parallel to walls, doors and structural members. The conduits shall be symmetrically set and evenly spaced with sufficient saddles to eliminate sagging.

All elbows, tees, draw in boxes and other fittings shall be of the inspection type and shall be securely fixed individually.

Conduit shall be installed to avoid all mechanical duct systems and other pipe systems and services and shall in all cases be at least 75 mm from heating pipes and at least 500 mm from boilers or furnaces.

Conduits - Cast in Concrete: Where conduits are cast in situ into concrete they shall be installed only with approval by the Principal.

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

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

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

13.1.4 Open, Unlined Drainage Channel Crossings

Where cables cross open, unlined drainage channels the cables shall be covered with a 75 mm thick continuously poured concrete slab which overlaps the sides of the cables by a minimum of 150 mm on both sides. The concrete slab shall be located 200 mm below finished ground level. An additional layer of marker tape shalt be provided directly on top of the concrete.

13.1.5 Communications Services

A minimum spacing of 150 mm shall be maintained between power and communications conduits when these are run in parallel.

A minimum spacing of 300 mm shall be maintained between power and communications conduits when these are run underground, with the communications conduits above the electrical conduits.

Separate communications conduits shall be installed between communications pits with a minimum of 25% spare conduits.

Conduits for communications services shall terminate onto floor or wall mounted boxes.

13.2 Penetrations, Fixings, Cutting and Making Good

13.2.1 Penetrations

Cable penetrations through walls, floors, ceilings and the like shall be sealed after cable installation.

Penetrations through damp courses are not allowed. Where penetrations are required for pipes entering a building at ground level, the pipes shall be run under the waterproof membrane and shall penetrate the waterproof membrane vertically at suitable locations.

13.2.2 Cutting and Making Good

All cutting and making good required for the installation of work shall only be undertaken by written approval. No welding to or drilling of structural members of the building will be permitted without approval.

13.2.3 Brackets and Fixing

All necessary brackets for mounting of wiring systems, etc, shall be provided by the Contractor. In general brackets shall be fabricated from hot-dipped galvanised mild steel for indoor areas and marine grade aluminium or stainless steel for outdoor/wet areas. The sections or plates shall be of adequate size and thickness.

Fixings shall be by means of bolts, nuts and washers (hot-dipped galvanised mild steel for indoor and stainless steel for outdoor/wet areas). Fixings into brickwork or concrete shall be by means of expansion bolts excepting that plastic plugs with stainless steel screws or locking pins may be used for securing conduit saddles. All holes for fixings shall be neatly drilled to the correct size and depth. Explosive powered fixings shall not be used.

Fixings to structural steel shall be in the form of the clamping to webs, rails, etc. Drilling or welding of structural steel members will not be permitted.

13.3 Earthing

Earthing shall be designed in accordance with AS/NZS 3000.

Earth system resistance values and fault loop impedance values at the worst points shall not exceed the values stipulated in the applicable sections of AS/NZS 3000.

Earth electrodes for the earthing system shall be copper plated or copper clad steel. Bare earth conductors shall not be used as earth electrodes.

13.4 Installation of Switchboards

Floor mounted switchboards shall be fixed to the floor with M12 hot dipped galvanised bolts. Where computer floors are modular-panel infinite access flooring, switchboards shall not be installed directly onto these infinite access floors.

Wall mounted switchboards shall be securely mounted with a suitable number of fixings.

Externally mounted switchboards shall not have top entry cables.

Switchboards shall be fitted with aluminium cable entry plates with spare plates for future expansion.

13.5 Cabling and Wiring Methods

13.5.1 Cabling in General

Cables shall be handled with care. When laying or snaking the cable no twists or kinks shall be allowed to occur. Throughout the installation twisted, kinked, knotted or crossed over cables shall not be permitted in any enclosure. Cable runs shall present a neat and workmanlike appearance.

Any damage occurring to a cable (including the serving) shall be reported to the Principal before work on the damaged cable proceeds.

Adequate slack shall be provided at all terminations, wiring boxes and accessories to facilitate servicing and re-termination of cores.

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

Cables shall be adequately supported along their entire length. Supports shall be provided as close as possible to the point of termination.

A nonferrous label of approved material shall be permanently strapped to each end of every power and control cable, before and after points where its route cannot easily be followed and at such other points as the Principal may require. The label shall be clearly and legibly marked indicating the cable number.

Unless otherwise approved by the Principal, single core cables forming part of a three-phase system shall be clamped together in trefoil, each trefoil clamp containing one conductor from each phase. For high current parallel circuits, the trefoil arrangements shall be such that impedance equalisation and minimum reactive loss is achieved.

The mechanical strength of cable clamps shall be adequate to restrain the forces generated by fault currents.

Cables shall not be run in a manner resulting in hysteresis and eddy currents being circulated in surrounding metal work or any steelwork forming part of the cleat.

Unused terminals in equipment shall not be used as connection terminals for looping control and power cables. Junction boxes, connection boxes, switchboards etc shall not be used as marshalling areas for cabling to other equipment.

All cable entries to equipment to be terminated shall be by cable glands. Wire armoured cables shall have their armour wires neatly terminated in glands designed for that purpose.

Any winch used to pull cables shall have automatic limitation of pull exerted. The pull shall not exceed that specified by the manufacturer for the cable and conditions applying. If winch ropes are used, they shall be attached to the cable armouring with steel mesh sleeves.

Cables shall be installed in continuous lengths without joints except where approved. In no circumstances shall cable terminations or connections be made inside cable ducting.

When not installed on racks or trays, cables shall be installed in conduit saddled to concrete masonry or steelwork or clipped by cable clamps to fixed Unistrut channels where approved by the Principal. Channels shall be of sufficient width to accommodate the cables in the run plus an allowance of 25% for future cabling.

All cables shall be supported at a maximum interval of 1000 mm or at lesser intervals, to prevent undue sagging. Cables in sloping and vertical runs shall be evenly supported at no greater than 600 mm intervals.

Apply cable ties at even spacings, trimmed and same hand orientation.

Any damage to civil works or steel, including paintwork, resulting from electrical installation works shall be 'made good' by the electrical Contractor.

Structural steelwork shall not be drilled, welded or cut to facilitate cable installation without the written approval of the Principal.

Ensure SCADA and ELV cabling systems are segregated from power cables in accordance with the Australian Standards.

13.5.2 Cable Trays and Ladders

Cable ladder and tray shall be of adequate width to accommodate the cables specified plus a 50% allowance for future cabling.

Where cable is run within ducting, allow 50% spare space for future cabling. The easy removal of a single wire or cable shall be considered to be the limiting criterion.

Ducting installed outdoors shall be provided with drain holes.

Power cables laid in racks or trays shall be in a single layer and shall be permitted to touch.

All tray bends, both horizontal and vertical shall have a minimum radius of 450 mm for power and control cables unless otherwise noted.

Cable ladder and tray shall have a maximum rung spacing of 300 mm and be supported on fabricated mild steel brackets welded or bolted to building structures. They shall be supported at intervals not exceeding the manufacturer's recommendations. Cables shall be fixed to sloping and vertical runs of cable ladder and tray by saddles, clamps or nylon cable ties.

Ducts, cable trays and ladders shall be bolted together by fish plates or other approved means. Bolts shall not protrude into the rack section which may damage cables during installation.

Cable trays, ducts and ladders shall be welded hot dipped galvanised steel or PVC. For outdoor installations, hot dipped galvanised steel shall be used.

Expansion joints shall be utilised between independent structures or where any straight section of duct, tray, etc exceeds manufacturer's recommendations. Continuous earth continuity shall be maintained across such joints by means of an earth strap for steel cable trays.

Where it is necessary to cut or weld steel cable ladder racks, the exposed metal shall be painted with a zinc rich paint approved by the Principal.

Steel cable ladder rack routes shall be bonded to the earth grid via 16mm green/yellow striped PVC covered cable at each end of the run, to the nearest available switchboard earth.

Peaked covers shall be fitted to ladder, tray and duct which are easily accessible, subject to direct sunlight or prone to build up of dust or materials, or subject to mechanical damage. For vertically-laid cable ladder tray and duct subject to the preceding conditions, flat covers shall be provided.

Where covers are fitted, they shall be clamped to the ladder, tray and duct to the approval of the Principal.

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

Where cable ladder, tray or duct is fixed to removable items of plant they shall be secured with clamps and bolts. Welding will not be permitted.

13.5.3 Cable Terminations and Wiring

Cables shall be clamped to the cubicle gland plate using approved weatherproof cable compression glands. Plastic weatherproof shrouds shall be provided and fitted for glands mounted outdoors.

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

Where it is required that PVC cables be connected to equipment that is too small to accommodate the gland, or if permanent wiring is provided with equipment, then cable shall be terminated in a conveniently located two-way junction box. The connection to the equipment from the junction box shall be made using flexible PVC coated metal conduit and approved fittings.

The unsheathed part of multicore cables shall be neatly laced with cable ties or other approved means.

Where screened instrumentation cables are specified, screening shall be continuous from the signal source to the receiver. Earthing of the screen shall be at the auxiliary racks only and shall be achieved by connection to the instrument earth busbar.

All cable terminations shall be made using pre-insulated crimp lugs unless approval is obtained from the Principal. Crimp lugs shall be crimped with an approved crimp tool. Crimping with electrician's pliers is not permitted.

Wire stripping shall be performed using an approved wire stripper. The wire shall be stripped to an extent that prevents the covering entering the terminal connection or crimping lug but does not allow the protrusion of bared wire from the terminal block or lug.

No more than two wires shall be connected to one side of any terminal. The two wires shall not be twisted inside the connection. The correct size and type of screwdriver shall be used for making terminal block connections.

The number and size of bolts used for the terminations shall be determined by the lug requirements. Where equipment terminals are not big enough, copper flags shall be fitted.

Hand operated crimping tools shall be of the type which will not release until full compression is applied. Hexagonal crimping dies shall be used on all cables of 70 mm2 cross section and above.

The cores of all control cables shall be run through and numbered with white engraved ferrules with black numbers corresponding to the relevant termination diagrams and equipment drawings. Grafoplast or equivalent are acceptable. Wrap around adhesive markers will not be accepted. Component numbers of the identifier shall be aligned and identifier clearly visible. Numbers shall read away from the point of termination.

Ferrules shall be of a type which will not slip off the ends of the cables and shall interlock to ensure that the numbers remain tightly together. Saddle type ferrules are not permitted.

Terminal strips shall be provided with the number of terminals required on the drawings plus 25% spare rail capacity. All spare cores shall be terminated. Each terminal shall be identified with a number.

13.6 Lightning and Surge Protection

13.6.1 General

In addition to the transient protection system at the SCA, lightning and surge protection equipment shall provide protection to instrument and electronic circuits against surges and transients induced in signal and power lines and antennas by lightning or electrical switching.

The manufacturer's instructions for earthing surge protection devices shall be rigidly adhered to. All earthing equipment required to carry out the manufacturer's instructions shall be supplied and installed. Earth resistance tests on each earth utilised for surge protection devices shall be performed and results reported in writing to the Principal within five (5) working days after completion of testing.

Lightning protection units for analogue signal wiring shall be suitable for use for 4-20 mA signals at the loop power supply voltage. The units shall be rated to withstand a peak impulse current of at least 10 kA for a 8/20 microsecond pulse (8 microsecond rise time, 20 microsecond exponential decay time) for line-to-line and line-to-earth transients and shall fail to the short circuit condition.

The units are not required to be resettable and each channel shall have a resistance of less than 40 Ohms.

Lightning protection units for mains power cables shall have a continuous rating of at least 3 A at 240 VAC. The units shall be rated to withstand a peak impulse current of at least 4 kA for 8/20 microsecond pulse and shall be capable of absorbing at least 130 J of energy.

The units shall provide both differential (active-neutral) and common (active- and neutral-earth) mode protection and shall be capable of being used in conjunction with a 10 mA earth leakage circuit breaker.

13.6.2 Building Lightning Protection

Requirements for lightning protection for buildings shall be assessed in accordance with AS/NZS 1768, and if required, a lightning protection system shall be designed to the requirements of this standard.

14 WORKS TESTING AND COMMISSIONING

14.1 General

Works testing and commissioning shall be carried out to ensure that the delivered works and the manner and method of all installation conform to the accepted construction and engineering practices, and that each piece of equipment is in satisfactory condition to successfully perform its functional operation.

All necessary meters, instruments, temporary wiring and labour shall be supplied to perform all required tests and adjustments of equipment and wiring installed and connected.

All test results shall be recorded and issued to the Principal.

14.2 Earthing

- Measure the earth resistance of the main earthing conductor.
- Check the earth continuity to all equipment.
- Check the earth continuity to metallic sheathed cables.

14.3 Cabling

- Measure the insulation resistance between cores and between all cores and earth using a 1000-volt megger. Resistance values of less than 10 megohms for 415-volt cables per cable run will not be accepted. Care shall be taken during these tests to ensure that no equipment likely to be damaged by the test voltages is connected to the cables.
- For three-phase power cabling, check and test correct phase rotation with numbers and colours.

14.4 Motors

- Manual turning of the rotor to ensure mechanical freedom.
- Insulation resistance at 1000V between phases and between each phase to earth.
- Check motor for run and direction of rotation.
- Record no-load currents.
- Functional check of control circuit and devices.

14.5 Lighting and Power Outlets

- Check all fittings and power outlets for correct polarity.
- Check the correct operation of all switching circuits.
- Check the power factor for all light fittings.
- Demonstrate that all emergency lights operate for a period of 1½ hours or longer.
- Additional tests required for emergency lighting in accordance with AS/NZS 2293.

14.6 400 Volt SCA

- With cable tails disconnected, check the insulation resistance between phases and between phases to earth using a 500-volt megger. Insulation resistance readings of less than 10 megohms will not be accepted.
- Test correct operation of all circuit protection and all control circuits.
- Injection tests of all protection and metering equipment.
- Functional test of all components.

- Check power factor reading that the reading is 0.95 lagging or better and not greater than 1 at various plant loads (i.e. various plant production rates).
- Additional tests required by the Supply Authority.
- All specified operational checks and tests including rotation, polarity, fuse ratings and overload and protection settings. All operational checks and tests may be witnessed by the Principal.

14.7 Electrical Interference

- Additional tests required in accordance with AS/NZS 1044, AS/NZS 1054 and AS/NZS 61000.3.6 and Supply Authority requirements.

14.8 Calibration Certificates

Copies of Calibration Certificates shall be provided for all instruments used in providing testing and commissioning results. Submit for approval any documents required by the Supply Authority.

On completion of tests, all links shall be closed and tightened, all fuses replaced, all terminations are tight, all electronic equipment, earthing, etc. have been reconnected and all covers replaced.

A minimum of five (5) working days notice of all tests shall be given in order that such tests may be witnessed by the Principal. Submit the test results within five (5) working days after completion of testing to the Principal.

14.9 Testing and Commissioning Process for Major Electrical Works

14.9.1 Introduction

The following sections indicate the typical processes for the testing and commissioning of major electrical works. The actual process(es) to be followed for each project will be subject to the complexity of the scope and nature of the electrical works. These sections are intended to provide guidelines for establishing a structured approach, plans and procedures for testing and commissioning.

14.9.2 Testing and Commissioning Plan

A “Testing and Commissioning” plan shall be developed for all works testing and commissioning. The plan shall allow sufficient time for testing (including Pre-FAT) and if necessary, re-testing of equipment and fit in with the overall project completion time. The plan shall take into consideration the experience obtained from previous sites of a similar type and complexity.

Before undertaking commissioning of the plant, all test instruments shall be calibrated by a NATA approved test authority within two (2) months of actual site usage. Test certificates shall be submitted to the Principal before commissioning commences.

14.9.3 Summary of Testing & Commissioning Process for Major Electrical Works

Testing and commissioning of major electrical works shall be carried in the following order:

- Contractor provides “Testing and Commissioning” plan
- Contractor provides testing equipment calibration documentation, Drawings, and Operations and Maintenance Manuals
- Contractor completes all Pre-FATs requirements and at the same time completes the “Pre-FAT Test Results Record Sheets”
- Contactor submits the completed “Pre-FAT Test Results Record Sheets” to the Principal for review

- Contactor completes FAT and submits the completed “FAT Test Results Record Sheets” to the Principal. The Principal will witness the FAT.
- Provided the Principal has accepted the FAT results and approved delivery, the Contractor installs the equipment on site
- Contractor provides written notification to the Principal of the proposed commencement of a pre-SAT or a SAT
- Contractor provides updated drawings, and Operations and Maintenance Manuals, testing strategy/plan
- Meet with the Principal at least one week prior to a SAT on a new type of site. This meeting will discuss the proposed commissioning methodology and issues relating to the particular type of site.
- Contractor completes all Pre-SATs and the “Pre-SAT Test Results Record Sheets” and submits the “Pre-SAT Test Results Record Sheets”. The Principal will witness the Pre-SAT. The Principal will advise the Contractor of the acceptance or otherwise of the Pre-SAT results;
- Contractor provides all relevant information and confirms date for the SAT;
- Contractor completes all SAT. The Principal will witness the SAT. The Contractor submits the “SAT Test Results Record Sheets”. The Principal will advise the Contractor of the acceptance or otherwise of the SAT results;
- Operator training; and
- Handover, after submission of test results, final Operations Maintenance Manual (OMM), Work-As-Executed drawings, any other documentations and operator training materials

14.9.4 Test Results Sheets

Test sheets are to be prepared by the Contractor and forwarded to the Principal for approval one month before any testing is to be carried out.

Test sheets to be provided before testing are:-

- Pre-Factory Acceptance Test (Pre-FAT) Results Record Sheets;
- Factory Acceptance Test (FAT) Results Record Sheets;
- Pre-Site Acceptance Test (Pre-SAT) Results Record Sheets; and
- Site Acceptance Test (SAT) Results Record Sheets.

Typically, the test results sheets will include, but not be limited to the following:-

- Test title e.g. Motor Starter AUTO operation;
- Purpose of test: e.g. prove operation of interlocks;
- Test conditions or configuration: e.g. Switch in AUTO position;
- Description of each test in sequential order;
- Expected result on local panel e.g. light on, relay energised;
- Acceptance criteria;
- Duration of test e.g. 1 minute for soft starter ramp up;
- Comments;
- Pass or Fail; and
- Sign off by tester, another witness from Contractor’s organisation and the Principal.

Typically, separate sheets shall be provided for:-

- SAT Confidence Tests;
- FAT/SAT visual check;
- SAT equipment location and completeness check;
- FAT/SAT Instrument Calibration;
- SAT functional check;
- FAT/SAT System Test;
- SAT equipment decommissioning checks; and
- FAT/SAT documentation check.

14.9.5 Factory Acceptance Testing

The switchgear shall be tested in accordance with the requirements of the appropriate Australian Standards and as required by authorities having jurisdiction, such as the electricity distributor.

As a minimum, tests shall include:

- Insulation resistance
- Power frequency voltage withstand
- Resistance of primary circuits and earthing circuits, including busbars, switching devices and earthing switches
- Verification of correct wiring
- Mechanical operation of all switch devices and interlocks
- Verification of instrument and control transformer ratios, polarities and connections
- Magnetising curves of current transformers
- Measurement of partial discharges of CTs and VTs
- Functional tests of control and protection circuits, including tests at the stated limits of control and auxiliary supply voltages
- Accuracy check of meters and transducers, at 25 %, 50 %, 75 % and 100 % of full scale, minimum
- Performance checks of protection relays at a minimum of four points on the operating curve, including pick-up
- 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
- Ductor test on busbars.
- Point to Point testing of interposing field I/O terminals to ensure that the I/O is wired to the correct point on the PLC/RTU. This shall also include 4-20 ma injection tests for analog inputs and 4-20mA analog output measurements for analog outputs.

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

Primary injection tests shall be performed on each metering current transformer and its associated meter(s) or transducer(s). As a minimum, these tests shall be performed at one half and at full scale values. If, due to limitations of test equipment, a phase-controlled 3-phase current test source is not readily available, 3-phase meters and transducers may be tested using single-phase current sources.

Where practical, FAT shall be made available for SW to attend.

Site Acceptance Testing

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

As a minimum, tests shall include:

- Insulation resistance
- Power frequency voltage withstand
- Resistance of primary circuits and earthing circuits, including busbars, switching devices and earthing switches
- Verification of correct wiring
- Mechanical operation of all switch devices and interlocks
- Verification of instrument and control transformer ratios, polarities and connections (if this has not been done in factory acceptance test)
- Functional tests of control and protection circuits, including tests at the stated limits of control and auxiliary supply voltages
- Accuracy check of meters and transducers, at 25 %, 50 %, 75 % and 100 % of full scale, minimum (if this has not been done in FAT)
- Performance checks of protection relays at a minimum of four points on the operating curve, including pick-up
- 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
- Injection test for protection relays
- Checks to validate all I/O
    - This will involve the manipulation of field I/O, where possible, to check the correct operation of inout and output devices.
    - Input devices shall be manipulated to provide the required input check to the PLC.
    - The operation of the device shall match the expected interpretation of the inout by the PLC/RTU. For example, when manipulating a low-level switch to simulate ‘level low’, the signal sent to the digital input (0 or 1) shall have the correct state to match the process condition.
    - The PLC/RTU shall be used to energise digital outputs where the activation of the end device shall be verified by commissioning personnel.
    - Similarly, the PLC/RTU will provide 4, 8, 12, 16 and 20mA outputs to all analog devices where commission personnel shall verify the correct operation of the end device.
    - Where possible, analog instrumentation shall be placed into ‘simulate’ mode and send a 4, 8, 12, 16 and 20mA signal to the PLC/RTU for verification within the PLC/RTU and/or SCADA.

14.9.6 Commissioning of Plant

Commissioning of the plant shall be carried out by the Contractor. This work shall include the adjustment of all variables to meet the specified requirements, the setting of motor overloads, safety settings, controls etc. to protect the plant from unsafe operation. In particular, the following work shall be undertaken:

- Calibration and adjustment of safety devices, overloads and other controls

- The correct direction of operation of motors
- Set-up and configuration of all instrumentation (digital and analog) including correct units of measure

14.9.7 Commissioning Data

Two copies of all data obtained from the above commissioning tests shall be submitted to the Principal for review. All data, certificates, and performance curves, etc., shall be provided and shall have been received and approved prior Completion.

14.9.8 Calibration Certificates

Copies of Calibration Certificates shall be provided for all instruments used in providing testing and commissioning results.

14.9.9 System Tests

The whole of the engineering services installed under the project shall be tested for operation under full load, normal and emergency operations.

Coordination with other third parties shall be required via the Principal to ensure that all systems can be tested simultaneously.

15 DOCUMENTATION FOR ELECTRICAL WORKS

15.1 Documentation to be submitted

Certificate of compliance electrical work (CCEW) Evidence of the electricity distributor's approval of the complete electrical installation shall be obtained by the installer and submitted to SWC before the electrical installation will be considered complete.

Electrical, instrumentation and control system documentation shall be prepared in accordance with the following standards:

- AS/NZS 1102 Graphical symbols for electro-technology; and
- ISA-S5.4 Instrument Loop Diagram;

Documentation to be submitted which describe the electrical, instrumentation and control system shall include but not limited to the following:

1. Drawing register or index;
2. Where relevant to the scope of the works, overall site plan showing major locations of electrical equipment and cable routes
3. Single Line Diagrams showing all equipment connected;
4. Schematic diagrams showing all equipment connected, including individual motor starter schematics;
5. Telemetry schematics;
6. Exterior switchboard layout drawings for all switchgear and control gear assemblies, enclosures, panels and equipment showing layout and mounting details of equipment and construction details;
7. Interior equipment layout drawings for all switchgear and control gear assemblies, enclosures, panels and equipment showing layout and mounting details of equipment and construction details;
8. Switchboard sectional drawings for all switchgear and control gear assemblies, enclosures, panels and equipment showing layout and mounting details of equipment and construction details;
9. PLC/RTU connection diagram;
10. PLC/RTU input and output schematics;
11. PLC/RTU input and output schedules;
12. Analogue Instrument Loop Diagrams;
13. Instrument schedules listing each item of instrument and including, tag number, purpose, accuracy, input and output details such as signal type, range, etc, operating range, calibration details, maximum working pressure, flange/mounting details, manufacturer/model;
14. Cable Schedules listing each power, instrumentation and control system cable including:
    - Cable number;
    - Origin;
    - Destination;
    - Type of cable;
    - Size of conductor;
    - Number of cores; and
    - Installation details such as cable route.
15. Equipment layout and cable route drawings and installation details;
16. Site conduit layout drawings and installation details;

17. Work As Executed (WAE) drawings
18. Shop Drawings; and
19. Operations and Maintenance Manuals.

15.2 Shop Drawings

The Contractor shall prepare fully dimensional and detailed working drawings for all main switchboard, motor control centre, control panels, distribution boards and conduits, cable trays and cable ladders, and to cover all aspects of the works. These drawings shall also include the complete set of design drawings. All drawings shall be in the format of the Principal's current version of AutoCAD.

Site work shall only be carried out based on "Shop Drawings" that have been formally approved. All access and required penetrations within the building structure shall be marked on drawings. Drawings shall be adequate to illustrate all installation requirements and shall include details of all equipment to be installed. The scale of the drawings shall be not less than 1 to 100 for building plans and 1 to 20 for details and shall be clearly legible and an A3 sheet.

Shop drawings are required for the following items:

- Switchboards layout drawings showing the arrangement of equipment within the switchboard, busbar arrangements and methods of achieving segregation, dust proofing, etc. complete with all necessary dimensions;
- Single line diagrams;
- Typical termination arrangement(s) for incoming supply outgoing wiring;
- Distribution board general arrangement drawings;
- Detailed layout drawings showing the arrangement of equipment, provisions for the termination of all-incoming cables, etc., complete with all necessary dimensions;
- Coordinated layouts of all conduits, cable trays, cable ladders, duct, light fittings, socket outlets etc., including all penetrations through walls, beams, slabs and underground;
- Physical layout of distribution frames and racks showing locations of termination modules and cables;
- Proposed termination sequence and labelling;
- Final details of circuiting including modified single line diagrams;
- Schematic diagrams of lighting control systems and emergency lighting including individual wire and cable numbering;
- Workshop drawings for all associated equipment panels and engraving details; and
- Equipment listings for all electrical components, the number required, ratings, make, model, catalogue number, etc.

15.3 Operations and Maintenance Manuals

15.3.1 General

The Contractor shall compile comprehensive operating and maintenance manuals for the mechanical and electrical equipment supplied.

A draft of the proposed manuals, complete with binders and all fully complete, shall be provided for the approval of the Principal not later than 6 weeks prior to the due date for practical completion of the work. Practical completion will not be granted until such time as the Principal provides written approval.

After approval three (3) copies of each volume shall be compiled and supplied to the Principal prior to the issue of the Certificate of Practical Completion. Each volume shall also be provided in an electronic format readable by Microsoft Word and PDF.

All diagrams and tables are to be numbered and the pages shall be numbered. A comprehensive index is to be included. The text shall be written in clear concise English and easily understood by a trained operator.

15.3.2 Contents

The Operation and Maintenance manuals shall include a full system description, component data, trouble shooting, spare parts, maintenance procedure schedule and reference drawings and document list. Subsections of the manuals shall be logically organised into:

- Switchboards and Controlgear Assemblies;
- Earthing System;
- Luminaires;
- Socket Outlets;
- Cables and Cable Support System;
- Other Equipment; and
- Trouble shooting procedures and fault finding recommendations for equipment.

Each subsection shall cover the following details:

- A full system description of installation;
- List and component data (brochures), where relevant;
- Records of settings and calibration of equipment (such as protection settings, timers, sensors, etc.);
- Maintenance operations and schedules;
- Recommendations for adjustments and routine maintenance procedures;
- Instructions for dismantling (where applicable); and
- Reference drawings.

The manuals shall also include the following:

- Safe Work Method (SWM) statements for operating each item of electrical plant. This shall include start up sequences, changeover sequences and shut down sequences. SWM's shall also include descriptions and operation procedures for shunt trips and interlocks;
- Test Certificates and Commissioning Reports for all tests including a list of tests to be carried out and shall contain signed test reports and certifications;
- All guarantees and warranties on all equipment supplied; and
- As-Built Drawings produced by the Contractor for approval, Shop drawings, final marked-up As-Built drawings and other relevant drawings not submitted for approval.

APPENDIX A – Shoalhaven Water Generator Standards